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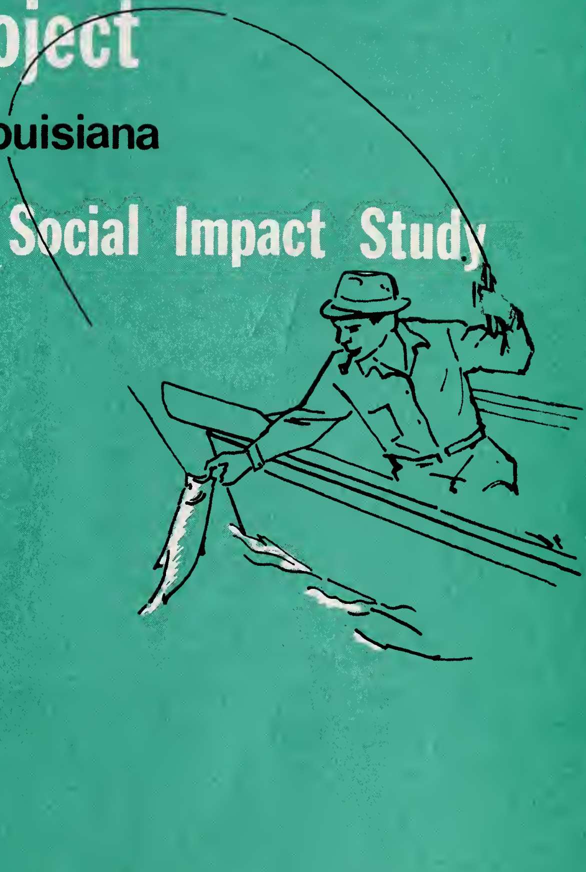
Middle Fork Bayou D'Arbonne Reservoir Project

Claiborne Parish, Louisiana

A Feasibility and Social Impact Study



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Preface

The research for this report was undertaken as a joint project of the Department of Rural Sociology and the North Louisiana Hill Farm Experiment Station of the Louisiana Agricultural Experiment Station. Full cooperation was received from Mr. Roy Aguillard, Director of the Louisiana State Department of Public Works, Mr. Leon R. Tarver, Jr., Director of the Louisiana Commission on Intergovernmental Relations, and some 70 Claiborne Parish leaders.

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Summary

The research reported in this bulletin was designed to provide background information for persons and agencies with a need to evaluate the proposed Middle Fork Bayou D'Arbonne Reservoir Project in Claiborne Parish, Louisiana. Emphasis was placed on feasibility and social impact factors. Findings of the study may be summarized as follows:

1. Claiborne Parish represents an area in need of resource development. The parish has been steadily losing population, especially in the younger adult ages, and this trend is projected to continue.

2. The people of Claiborne Parish are anxious to improve the economic opportunity structure within the parish and have initiated several projects with this objective in mind. The damming of the Middle Fork of Bayou D'Arbonne to form a reservoir is one of the projects proposed.

3. Interviews conducted with leaders of the parish, persons determined to be knowledgeable and/or influential, indicate a very strong local support for the project. This support stems for the most part from a very positive experience with Lake Claiborne, which was developed in the parish about a decade ago.

4. Study of the relocation and property acquisition problems indicates that neither will be serious. The number of landholders is small, there appear to be no permanent dwellers in the area, and the land is exclusively in hardwood forests.

5. Estimates of the user population provide evidence that over 600,000 persons live within 50 miles of the proposed reservoir site and that 1.6 million people are no farther than 100 miles from the site. This is a population base large enough to assure a market for the reservoir as well as for the other lakes and reservoirs in the region.

6. The planning for a reservoir in a relatively depressed rural area is in keeping with the rural development and outdoor recreation development objectives of the state and nation. In fact, it would seem an ideal contributing project to the programs being implemented under such Federal statutes as the Land and Water Conservation Act of 1965 and by state agencies such as the Louisiana Bureau of Outdoor Recreation.

7. The conclusion reached in light of the findings of the study is that the "Middle Fork" project is feasible and will have a positive social impact. It is recommended that the proposal be submitted to appropriate federal and state agencies for consideration for support.

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Middle Fork Bayou D'Arbonne Reservoir Project—Claiborne Parish, Louisiana: A Feasibility and Social Impact Study

Alvin L. Bertrand, Project Leader*

Background and Setting

Introduction

There have been unprecedented efforts to improve the "opportunity" structure in rural America within the past decade. Perhaps the most significant action at the national policy level was the enactment of the Rural Development Act in 1972. This act provided for programs designed to accelerate the development of rural areas and directed federal agencies to give the highest priority to the implementation of these programs.[1] This report, prepared by members of the Department of Rural Sociology Research, Louisiana Agricultural Experiment Station, in collaboration with the Superintendent of the North Louisiana Hill Farm Experiment Station, includes the findings of a research effort designed to contribute to the rural development mission in Louisiana. The project was undertaken upon invitation from civic and public agencies in Claiborne Parish, Louisiana, and could not have been completed without the cooperation of parish leaders. The cooperation and help of the State Department of Public Works and the Louisiana Commission on Intergovernmental Relations is also gratefully acknowledged.

The reader of this report should be aware that it is not concerned in a specific sense with the economic impact of the proposed reservoir. This important aspect of the total "impact" study is being prepared by members of the Louisiana Polytechnic University Faculty.

Motivation for the Reservoir Project

Claiborne Parish is one of several parishes in the state that have not prospered in the last quarter century. This lack of prosperity has been attributed to the mechanization of farms, which has displaced many smaller farmers and laborers, and the lack of industrial development. A recent study by the Coordinating and Development Council of Northwest Louisiana (May 1974) indicates that the future of the parish will continue to be dim unless something is done to reverse current trends. Among other things, the Council predicted a continued relatively rapid drop in population in the parish to and beyond 1990. The decrease in population was seen by the authors of the Council report as curtailing economic activity and, added to the lack of necessary transportation and public utility services, unduly disrupting chances for orderly growth and development.

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*The authors of this report, in addition to the Project Leader, are: Stephen E. Doeren, Kevin B. Smith, Walter E. Stead, and Howard F. Thomas.

[1] See: *Rural Development: Fifth Annual Report of the President to the Congress on Government Services to Rural America* (Rural Development Services, U.S.D.A., Washington, D.C., 1974).

Faced with the bleak outlook outlined in the paragraph above, the Claiborne Parish Planning Commission and other agencies and individuals in the parish have attempted to inaugurate programs to reverse the downward trends of the parish. Rather vigorous campaigns are in the planning or implementation stage to attract new industry, better utilize land and water resources, improve living conditions and educational facilities, and upgrade recreational opportunities. The Middle Fork Bayou D'Arbonne Reservoir Project is one of the major efforts initiated in keeping with the above objectives. It is seen by local planners as one of the undeveloped natural resources of the parish, one which can contribute substantially to the improvement of the social and economic conditions of its residents.

Location and Description of Claiborne Parish

Claiborne Parish is located in the northwestern part of Louisiana. It is bordered on the north by the state of Arkansas, on the south by Bienville Parish, on the west by Webster Parish, and on the east by Union Parish; Lincoln Parish is on its southeast corner. The parish and its existing network of roads and waterways is shown in Figure 1.

It is of interest to note that Claiborne Parish was formed when Natchitoches Parish was divided in 1828. However, it was later divided into several other parishes or parts of parishes, achieving its present size in 1873. Some 763 square miles is included within the land area of the parish, of which 85% is classified as in agriculture or open space. For the most part, the topography of the parish varies from rolling to hilly, although there are no sharp or high elevations. The primary lanes of transportation in the parish, as can be seen in Figure 1, are state roads, although a federal highway stretches across its northwest portion.

Gas and oil production represents the chief industrial activity in Claiborne. The major farming activity in the parish relates to the production of livestock and poultry products. These types of enterprises are followed in importance by crops of various types and forest products.

In essence, it can be said that Claiborne Parish is not highly industrialized, nor is it an intensive farming area. These characteristics contribute to its problems of growth and development, as will be highlighted in the report being prepared on the economic trends in the parish.

Population Characteristics and Trends

At the time of the 1970 Census, 17,024 persons resided in Claiborne Parish.[2] Of these, 8,049 were males (47.3%) and 8,975 were females (52.7%). The population was almost equally divided between blacks (50.1%) and whites (49.9%).

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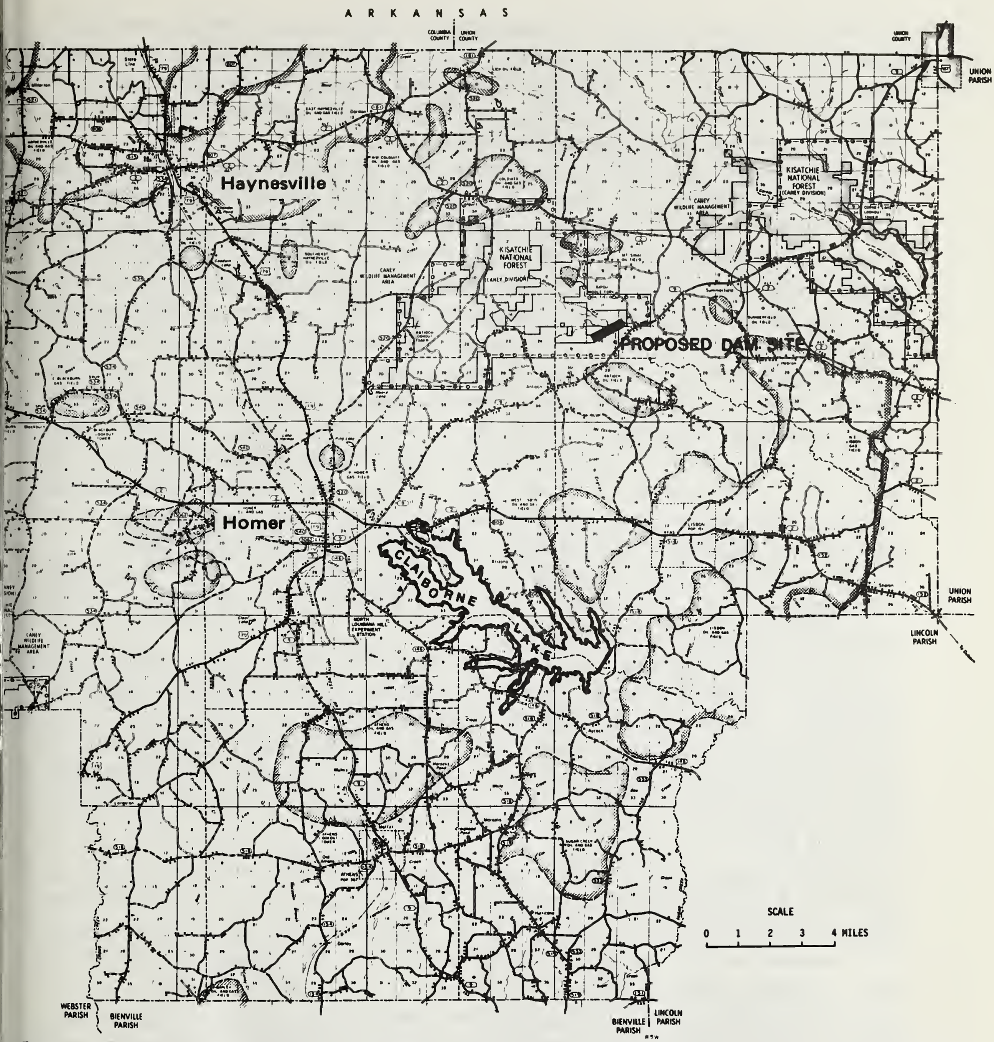
[2] Unless otherwise specified, all references to Census data will be to the various reports of the Bureau of the Census, U.S. Department of Commerce.


ARKANSAS
COLUMBIA COUNTY
UNION COUNTY
UNION COUNTY
UNION PARISH
Haynesville
KISATCHIE NATIONAL FOREST (CANEY DIVISION)
CANEY WILDLIFE MANAGEMENT AREA
KISATCHIE NATIONAL FOREST (CANEY DIVISION)
CANEY WILDLIFE MANAGEMENT AREA
PROPOSED DAM SITE
Homer
CLAIBORNE LAKE
NORTH LOUISIANA HILL EXPERIMENT STATION
CANEY WILDLIFE MANAGEMENT AREA
UNION PARISH
LINCOLN PARISH
SCALE
0 1 2 3 4 MILES
WEBSTER PARISH
BIENVILLE PARISH
BIENVILLE PARISH
LINCOLN PARISH

e 1.—Map showing location of roads, towns, and other features of Claiborne Parish.

Agewise, 5,896 (34.6%) of the individuals residing in the parish were 18 years of age or younger. There were 8,224 persons between the ages of 18 and 65 (48.3%) and 2,904 (17.1%) persons over the age of 65. Parenthetically, it may be noted that an extremely high percentage of the parish's total population was in the so-called dependent ages—i.e., below 18 years and over 65 years of age. The median age of the people living in the parish was 33.3 years.

Homer—the largest city in the parish—had a population of 4,483. The second largest and only other center classified as urban in the parish is Haynesville, which had a population of 3,055 in 1970. It is interesting to note that the population of Homer was 51.1% black in contrast to the population of Haynesville, which was only 35.9% black.

The total rural nonfarm population of Claiborne Parish was 8,217 (48.3%) in 1970. Of this number, 3,536 were white (43.0%) and 4,681 were black (57.0%). A relatively small percentage of the rural nonfarm population resided in the villages of Athens (387 persons), Lisbon (151 persons), and Junction City (159 persons).

There were only 874 persons classified as farmers in Claiborne Parish in 1970. Of these, 564 were white (64.5%) and 310 were black (35.5%).

In 1970, 60.9% of the males and 32.0% of the females over the age of 16 in this parish were in the labor force. Of these, 1,665 (31%) were black and 3,708 (69%) were white. Approximately one-fourth of the persons in the labor force were employed in blue collar (manufacturing) jobs in the parish in 1974. This percentage is quite high when compared with a state average of 15.9%. One-third (34.2%) of the workers in the parish were in white collar jobs, whereas the statewide average was 45.2%. The government employed 19.0% of the persons in the parish labor force (the state average was 17.2%). Only a very small percentage (4.6%) of the labor force was composed of farmers and farm workers. The remainder of the parish labor force (18.3%) was divided among professional occupations (i.e., physicians, dentists, and educators) and service workers.

The median family income for Claiborne Parish in 1970 was $5,347 as compared with a statewide average of $7,530. The per capita median income for the parish was $4,864.

Of the 4,004 families in Claiborne Parish in 1970, 1,322 (33.0%) were considered to have incomes below the poverty level. This percentage indicates the economic problems that face the parish. Statewide, only 21.5% of the families are at this economic level. The mean income for the poverty families in Claiborne Parish was $1,967 annually. Of all the families in the parish, 13.2% lived on public assistance or public welfare income in 1970.

The average person over 25 years of age in Claiborne Parish had completed 9.3 years of school in 1970. This was well below the Louisiana average of 10.8 years. Only 26.3% of those persons over 25 years of age had earned a high school diploma (24.7% of the males and 27.1% of the females); only 13.9% had obtained some college education and only 7.0% had earned a college degree. Only 78.1% of all children between the ages of 14 and 17 were enrolled in school in 1970, as compared with a state average of 89.5%.

When compared with that in the rest of the state, the health care services delivery system of Claiborne Parish appears somewhat overworked. In 1970, there were eleven physicians in general practice, no surgeon, and eight dentists in the parish.[3] The state ratio of persons per physician was 957. By comparison, the ratio in Claiborne Parish was 1,547 —a difference of over 40%. When it is recognized that Louisiana's ratio is considerably higher than the national average, the figures for Claiborne take on even more meaning.

Population trends are one of the best indicators of recent developments in Claiborne Parish. In 1937 the parish had a population of 34,800. By 1950 this figure had declined by 27.9% to 25,063. Beteeen 1950 and 1960 the number of people dropped another 22.6% to 19,407 persons; and between 1960 and 1970 the population decreased to 17,024 (another 12.3% decline). Very obviously, the economic problems facing Claiborne Parish are related to its population base. With fewer and fewer taxpayers and consumers, it becomes increasingly harder to provide the services which represent an acceptable level of living.

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[3] Beverly B. Baird and Michael H. Moskowitz, eds., *Louisiana Parish Profiles* (New Orleans, Louisiana, Louisiana Regional Medical Program, 1972).

The declining population of Claiborne Parish is associated with a migration trend out of the parish, especially from rural areas. This phenomenon is, of course, very characteristic of the state and national trends. The urban segment represented 39.6% of the total parish population in 1960, whereas the rural population comprised 60.4%. In 1970, the urban residents comprised 44.3% of the population and the rural residents totaled 55.7%. This change takes on added importance when it is considered that there are no urban places with as many as 5,000 people in the parish.

Another significant fact that must be studied in analyzing the migration problem in Claiborne Parish is the shifts that occurred in the so-called working aged population. From 1960 to 1970, 8.2% of the white males and 18.8% of the white females between the ages of 15 and 19 left the parish. The black population declined in this age group even more during the same period, with 27.6% of the males and 23.3% of the females leaving. Even more startling is the finding that there was a decline of 54.8% of the young white males in the 20-24 year age range. Nearly as many females in these ages left the parish, 44.2%, or four of every ten. Two-thirds of the young black males (66.9%) ranging in age from 20-24 years and three-fifths of the black females (59.4%) in this age class left the parish in the decade of the sixties. Of those persons in the age group 25-29, there was a 50.0% decline in the white male population and a 50.0% decline in the white female population. Considerably more of the blacks in this age group, 69.6% of the black males and 61.3% of the black females, left the parish during the decade 1960-70.[4]

Projections for 1980 indicate that the population of Claiborne Parish will decline approximately 12.3% during the 10-year period 1970-80. This includes a projected 8.2% drop in the white male population, a 9.1% drop in the white female population, a 13.8% drop in the black male population, and a 16.5% drop in the black female population.[5] The magnitude of the above migration trends highlights the greatest problem of Claiborne Parish: how to provide an opportunity structure for its younger people. This explains part of the concern over projects such as the Middle Fork Bayou D'Arbonne reservoir.

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[4] Roger L. Burford and Sylvia G. Murzyn, *Net Migration for Louisiana and Its Parishes 1960-1970* (Baton Rouge, Louisiana, Division of Research, College of Business Administration, LSU, 1972).

[5] Georgia L. Christou and Harris S. Segal, *Population Projections to 1980 and 1990: Louisiana and Its Parishes* (New Orleans, Louisiana, Division of Business and Economic Research, College of Business Administration, LSUNO, Research Study No. 18, 1973).

Attitudes and Feelings of Parish Leaders Regarding the Proposed Project

It is a principle basic to development programs that local leaders must be aware of, understand, and support a project if it is to be successfully implemented. Specifically, many studies have shown that local involvement and support are especially significant factors in water resource development.[6] It was for this reason that the decision was made to interview persons in Claiborne Parish identified as knowledgeable and/or influential; in other words, local opinion and action leaders.

Selection of Influentials

The study group developed criteria for the selection of knowledgeables and influentials as follows: he or she must reside in the parish, must be knowledgeable about what goes on in the parish, and must possess some characteristic or hold a position such that a degree of influence could be exerted on at least some residents of the parish. No quotas were established with reference to race or sex; rather, individuals were sought out in a purposeful manner. However, an attempt was made to reach influentials of all types, including blacks as well as whites, women as well as men, open country residents as well as town residents, and persons living near the proposed site of the reservoir as well as persons not residing in the immediate vicinity of the proposed reservoir site. Names of potential interviewees were obtained in three ways: from an initial list prepared by a longtime resident of the parish; by asking the interviewees on this list if he/she could recommend individuals who met the requirements for leaders; and by seeking out certain key office holders, such as the sheriff and school superintendent, for interviews on the basis of their leadership positions in the parish. Altogether, 70 parish leaders were interviewed; however, only 67 different families were represented.

Characteristics of Influentials

Approximately three out of four (76%) of the persons interviewed in Claiborne Parish were white, the remainder were black. Over four-fifths (84 percent) were male and 16% were female. Of the latter, four were black.

Slightly less than one-third of the influentials (32%) were between 40 and 49 years of age, and about the same number (30%) were in the age range 60 through 69 years. One-quarter (24%) ranged in age from 50 to 59 years, while 11% were younger than 40 years. The youngest interviewee was 26 years of age.

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[6] Ted L. Napier, *An Analysis of the Social Import of Water Resources Development and Subsequent Forced Relocation of Population Upon Rural Community Groups:* An Attitudinal Study (Columbus, Ohio, Dept. of Agri. Econ. and Rural Soc., The Ohio Agricultural Research and Development Center, 1974); Kenneth Wilkinson, *Local Action and Acceptance of Watershed Development* (State College, Miss., Water Resources Research Institute, 1966); John H. Peterson, Jr. and Rodney N. Friery, *Community Organization Programs and Relationships in Watershed Development* (State College, Miss., Water Resources Research Institute, 1972).

Eighty-seven percent of the influentials interviewed had resided in Claiborne Parish for at least ten years, and more than half of them had lived in the parish all their lives.

Nine out of every ten of the influentials interviewed were married, and three of every four (72 percent) lived within the limits of a town.

Slightly less than one-fifth of the informants (18%) had no formal educational experience beyond high school, while two-fifths (40%) had achieved some college or vocational-technical training. Just over two-fifths (42%) had earned at least a four year college degree.

Only 6% of the influentials reported an annual family income of less than $7,000. By contrast, 16% said the income of their family was over $25,000 annually. Most (64%) had family incomes ranging from $10,000 to $25,000.

Two-thirds of the influentials interviewed (67%) held membership in at least one or more organizations of a civic and/or public nature; and over half held membership in two or more such organizations.

The influentials of the parish ranked high on the occupational scale. Two-thirds of them (67%) held positions classifiable as either "professional, technical, and kindred workers" or "managers, officials, and proprietors."

It is clear from the above findings that the group selected as influentials were different from the average citizen in Claiborne Parish. They were much better educated, had higher incomes, held better jobs, and maintained a higher level of social participation in civic and community organizations.

The Interview Procedure

A decision was made by the study group to utilize a depth interview technique in the interviewing of knowledgeables and influentials. Toward this end, an interview guide including five basic questions was prepared. (See Appendix A.) The first two questions were concerned with Lake Claiborne and were designed to determine the interviewee's knowledge of and experience with this earlier lake project in the parish. It was felt that Lake Claiborne would provide a frame of reference, positive or negative, for contemplating questions relative to the proposal for a second lake. Parenthetically, it can be noted that Lake Claiborne is located about two miles southeast of Homer. (See Figure 1.) The lake was formed by damming Bayou D'Arbonne, with the project being completed in 1966. The lake drains 133 square miles; when full, it has an elevation of 185 feet, a surface area of 10 square miles (6,400 acres), a volume of 100,000 acre-feet, and an average depth of 16 feet.

The last three questions in the interview guide were addressed to the proposed reservoir project. All questions were designed to be used in an unstructured fashion, that is, in an ordinary conversational manner. For the most part, interviews were taped, and transcribed at a later date. Generally speaking, interviews were held in the office, work place, or home of the individual. After interviewees had answered questions related to the reservoir project, they were asked to provide information relative to their age, occupation, residence, marital status, and income.

All the interviewing was completed in two days. In this regard, strenuous effort was made to minimize contamination, that is, the opportunity for a person already interviewed to discuss the questions asked of him with a prospective interviewee.

None of the seven persons who served as interviewers reported any special problem or difficulty. On the contrary, all were impressed with the cordiality and cooperation they received. Only one turndown was reported.

Responses of Influentials

The responses of interviewees are reported in this section. The reader is referred to Appendix A for the specific questions which were addressed to respondents.

Familiarity with Lake Claiborne—All of the influentials said they were acquainted with Lake Claiborne. Furthermore, almost all of them (94%) had personally used the lake; only four of them had not used the lake.

When the 63 influentials who had personally used Lake Claiborne were asked in what manner(s) they had used the lake, one answer stood out emphatically among the responses given—fishing. The next most frequently mentioned use of the lake was for water skiing, mentioned by 17% of the respondents. Picknicking (16%), boating (14%), ownership of property (10%), swimming (8%), hunting (5%), camping (3%), and miscellaneous uses (6%) were also identified as uses made of this facility.

It is noteworthy that the four influentials who had not personally used the lake had discussed the lake with persons who had used it. They characterized the general reaction of their friends who had used Lake Claiborne as being favorable to extremely favorable, as did all the other persons interviewed.

Evaluation of Lake Claiborne—When asked to give their evaluation of Lake Claiborne, 86% of the influentials responded in a manner which was judged to be favorable. In fact, over half of those interviewed were strongly favorable in their comments. Comments such as: "A definite asset to the parish," and "a boon to the community" were common. Only seven individuals (10%) gave replies interpreted as a neutral evaluation, and just two persons gave an unfavorable evaluation. However, none gave a response judged to be strongly unfavorable. There is no doubt that the people of Claiborne Parish are very pleased with Lake Claiborne.

When queried as to the impact of Lake Claiborne upon the parish, one reply stood out among the responses given by parish influentials—this was that direct economic benefits had accrued to the parish as a result of the lake. Over nine-tenths of the influentials voluntarily mentioned the economic benefits of the lake in addressing themselves to the question of its contribution to the parish. Typical statements were that it stimulated the local economy by bringing in outside money; that it helped attract industry to the area; and that it stimulated the building of homes and second homes. All these types of activities were seen as helpful to local business enterprises and adding to the local tax base.

Another frequently cited positive impact of the lake was increased opportunitites for various types of outdoor recreation. This benefit was mentioned by over one-third (36%) of the influentials interviewed. Another one-third of the persons quizzed on the subject felt that the lake had contributed to the increase in population within the local area, both in attracting permanent residents (mostly retirees) and in bringing summer and vacation visitors. Other advantages of the lake cited were the beauty it lent to the parish, the important water storage function it performed, and the fact that it brought an airport to the locality. Altogether, the 67 community influentials collectively gave 115 benefit type responses for Lake Claiborne.

When asked to identify negative features of Lake Claiborne, the influentials were not nearly as vocal as in the naming of benefits. They seldom registered complaints or grievances, and only 25 persons could think of negative impacts of the lake. It is interesting to note that only one complaint was mentioned by more than three of the influentials interviewed—this was that there was limited or no access to the lake for those persons who did not own lots on the lake. Since most of the shore line of Lake Claiborne is privately owned, this appears to be a well founded complaint. One-fifth of the respondents alluded to this problem. The next two most frequently mentioned problems associated with the lake were that the lake increased the likelihood of recreational-related accidents and that the lake was overcrowded, especially during the summer months. A few other "potentially" negative features were cited, *but none by more than one person.* They were expressed as conjectures that the lake would increase the probability of flood-related problems; that visitors to the lake might account for an increase in crime; that visitors to the lake might bring liquor to what was once a "dry" area; and that the lake might "unfortunately" encourage people to spend money on recreational-related items which could well be spent on more "relevant" aspects of life.

All in all, the people of Claiborne have had what they recognize as a good and beneficial experience with Lake Claiborne. There is no doubt that this experience served to condition their reaction to the proposal for a new lake, as described in the following section.

Familiarity with and Overall Feelings About the Proposed Reservoir Project.—All of the community influentials were acquainted with the proposal for a second lake in the parish, to be created by damming the Middle Fork of Bayou D'Arbonne. This finding is impressive in that it verifies that this project has been widely known and discussed.

After establishing their acquaintance with the project, interviewees were asked: "What is your overall feeling about such a project?" (See Appendix A, Question Number 3.) It was clear from the answers to this question that the people of Claiborne Parish are overwhelmingly in favor of the proposed project. Approximately nine-tenths of the community influentials (91%) made statements indicating they were in favor of the proposed project. Over half of the respondents (52%) were strongly in favor of the project and enthusiastic in their support of it. Typical comments of this group were: "I am all for it. It would bring more people into the area," "I am 100 per cent for the project. It would add to the economy of the parish," and "It will boost business in the whole parish, bring in tourists."

Only three persons gave responses that were judged to express a neutral feeling about the project, and just two persons were strongly opposed to it. Two other persons said they were not in favor of the project, but were not strong in their opposition to it.

When queried as to the specific types of benefits anticipated from a second lake in the parish, two responses were prominent among those given by community influentials—an anticipated increase in economic benefits and increased recreational accessibility for those persons not able to own lots on Lake Claiborne. The following observation was typical: "It would provide those people not financially able to own a campsite with a place to fish, especially those who 'bank' fish." It is worthy of comment that the two benefits named most frequently related directly to experiences derived from Lake Claiborne. The positive economic impact of Lake Claiborne and the fact that it is now overcrowded were frequently mentioned in the context of expected benefits from the new project. With regards to accessibility, it was especially noted by the black interviewees that a significant proportion of the shore line of the proposed reservoir will be federally owned. The pressure (overcrowding) on Lake Claiborne was mentioned as a strong justification for the Middle Fork project by one-fifth of the influentials. Other benefits that could be seen from a second lake were an increase in the population of the parish, both in terms of residents and visitors; electricity generation, water storage, second homes, and the esthetics emanating from a large body of water.

When questioned as to what problems a second lake might create for the people of the parish, the interviewees mentioned several things. Fourteen persons wondered about the displacement of people, a subject covered in a subsequent section. Five individuals were afraid the flooding necessary would be detrimental to hunting in the area and four persons thought it would increase taxes. Other problems mentioned by no more than one or two interviewees were that property value of lots at the site of Lake Claiborne would decrease; that the reservoir would result in the destruction of part of the national forest; that the capital outlay that would be required on behalf of the parish could be put to better use; that the construction of the reservoir would increase recreation-related accidents; that the reservoir would probably be regulated by too many governmental restrictions, such as limiting the amount of land upon which private buildings could be constructed; that the construction of the reservoir would probably increase the amount of garbage and pollution in the area; and that the expenditures allocated for the construction of the reservoir would probably be too restrictive.

By way of summary, it is significant that 102 benefit-related responses were given in contrast to only 29 problem-related responses. The latter were concentrated in the responses of a relatively small number of individuals.

Impressions of Sentiment in the Parish Toward the Project.—Two-thirds of the influentials had discussed the proposed project with others in their community and/or parish. These discussions apparently took place in a variety of social settings, both formal and informal. Their evaluation of their friends and acquaintances' feelings may be summarized as follows.

Over nine-tenths of the influentials who had discussed the proposed project with others in their community and/or parish stated that the general reaction of those persons with whom they had talked was favorable. One person put it this way: "All the people I know are certainly in favor of it. The general sentiment is that it is much needed and wanted." Two persons had noted a neutral sentiment regarding the project among some of their friends, and one person reported that his contacts were not in favor of the project. Again, however, there is no question about the overwhelming positive nature of thinking in the parish relative to the proposal.

Opinions About Willingness of Parish Officials to Support Project—Community influentials were reminded that sometimes it is necessary for local groups to raise matching funds and to assure the provision of services such as roads and utilities before funding for a major development project can be obtained from state or federal sources. They were then asked whether or not they felt that the officials of their parish would commit themselves to this extent for the proposed reservoir. A follow-up question, "Would you personally support such action on the part of your parish leaders?" was designed as a probe for the respondents' depth of feeling. (See Appendix A, Question Number 5.)

The community influentials interviewed overwhelmingly expressed the belief that their parish leaders would be willing to support the reservoir project with matching funds, provided the latter were not too high. There was also a strong feeling that parish officials would attempt to provide services such as roads and utilities, if this was necessary in order to obtain funding for the reservoir. Four of every five of the persons interviewed were of the opinion that the parish leaders would commit themselves in this way. The general feeling detected was expressed by one individual in this manner: "Our leaders would be willing to support the project to the extent they could." Only 11 persons felt that the local police jurors and other parish officials would not lend great support to the project. However, two persons were uncertain as to how their local officials would react.

An even greater percentage of the influentials (85%) stated that they would personally support their officials in action designed to bring a second lake to the parish. Only five individuals were not willing to lend their personal support to the project, and an equal number were uncertain at the time of the interview as to whether they would support such action.

In concluding this review of the responses of influentials and knowledgeables in Claiborne Parish relative to the proposed development, it is clear that there is strong support for the project. This fact should encourage support and subsidy from state and federal agencies.

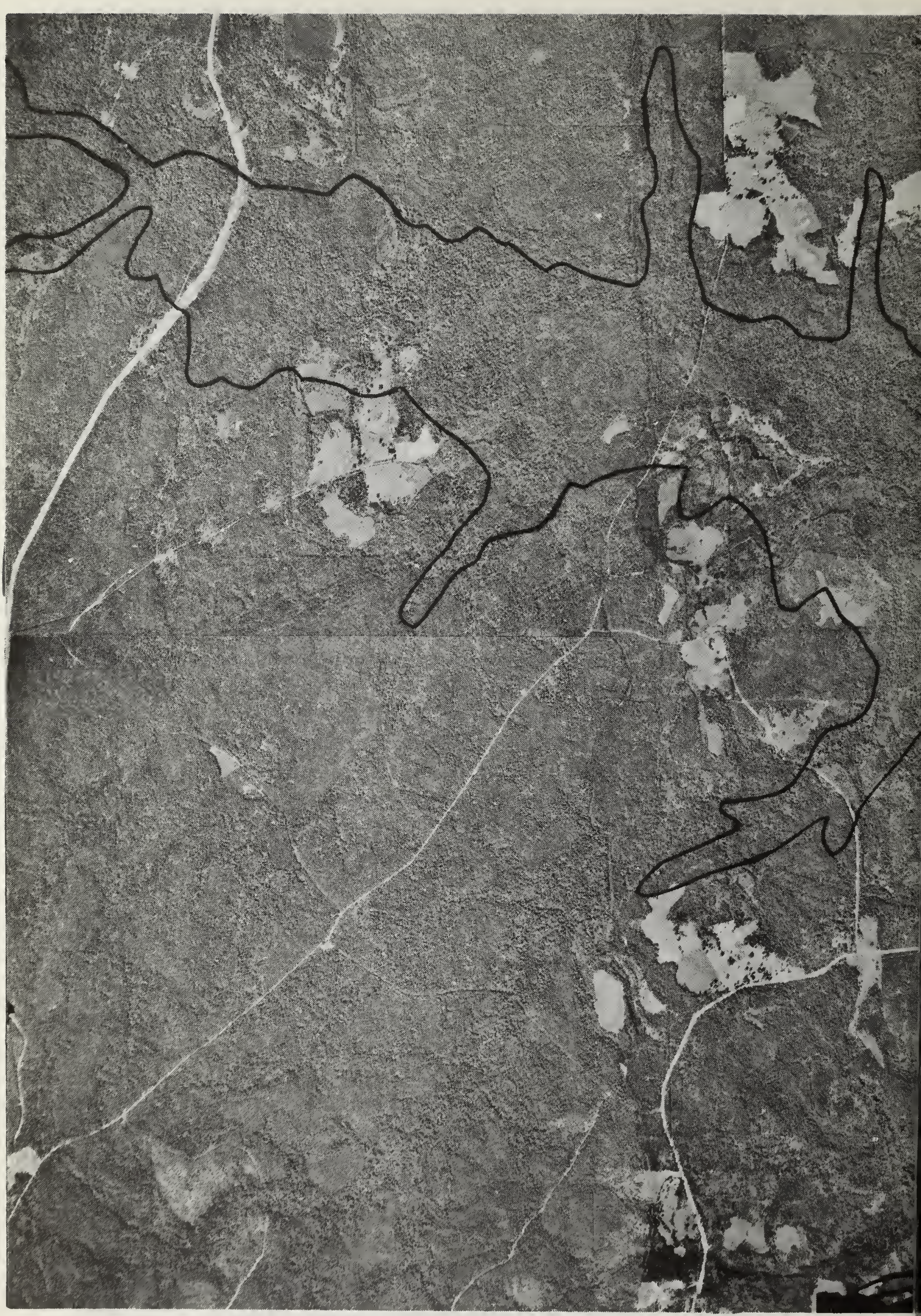
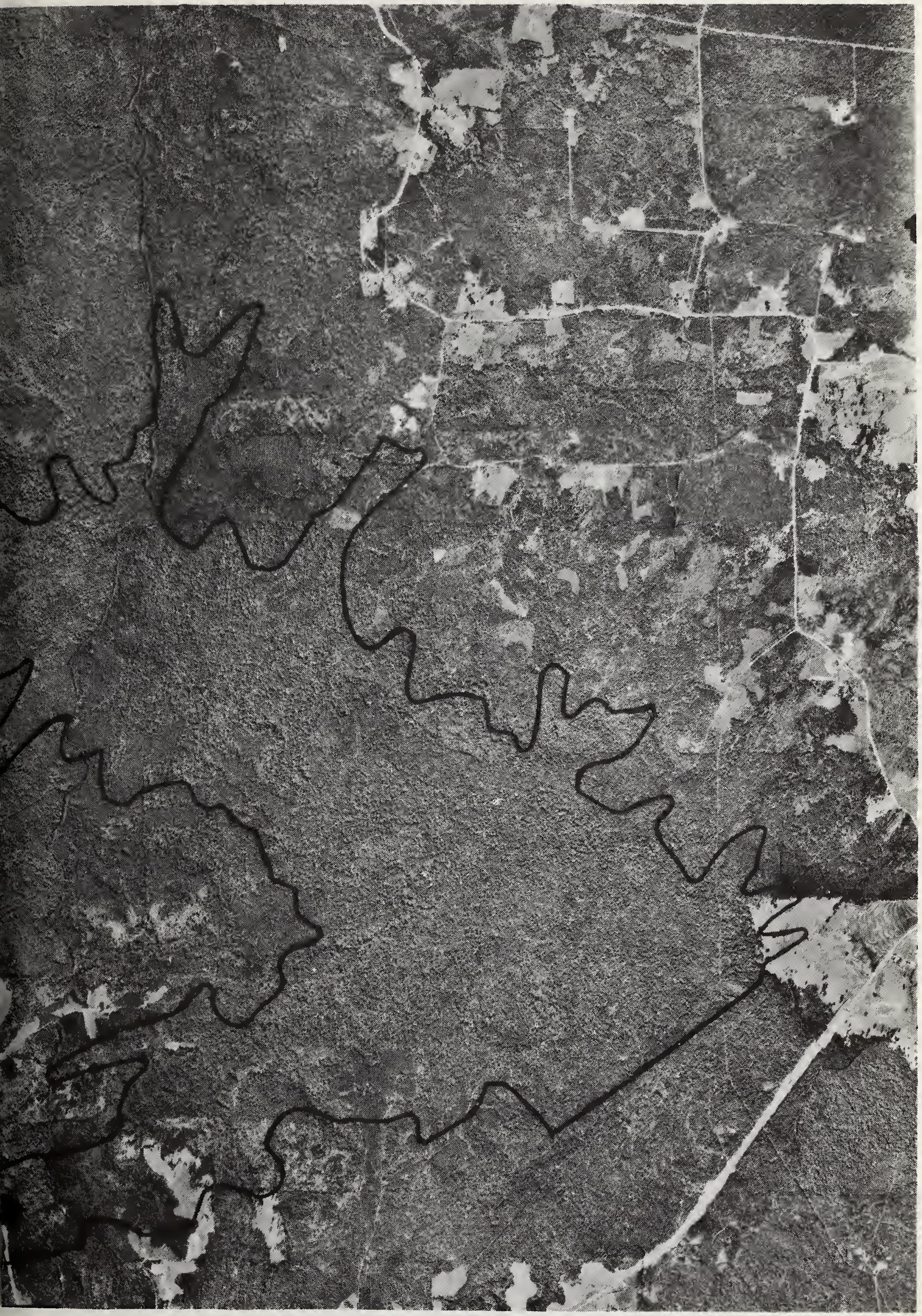


Figure 2.—Photograph o



red by proposed reservoir.

The Problems of Relocation and Property Acquisition

One of the most important considerations in the planning for a reservoir project is the magnitude of the relocation and land acquisition problems. In fact, the importance of this type of problem is why such projects are generally located in rural areas of the state and nation.[7] Obviously, highly urbanized areas have such concentrations of people and ownership units that it is an almost impossible task to acquire the land necessary for a sizable water impoundment development.

With the above considerations in mind, a study was made to determine the dimension of property acquisition and relocation problems with respect to the proposed Middle Fork Bayou D'Arbonne reservoir project. Fortunately the State Department of Public Works engineers had surveyed the area and mapped the approximate boundaries of the reservoir at its completed stage. (See Figure 2 in center fold.)

The Relocation Problem

The first part of the investigation with regards to the above noted problems was devoted to a determination of the number of persons who might have to be relocated before water impoundment could begin. Again, fortunately, it was possible to find relatively recent aerial photographs of the whole area to be involved. These photographs were on file in the local office of the Agricultural Stabilization and Conservation Service, U.S. Department of Agriculture. The outline of the shoreline of the proposed reservoir, worked out by State Department of Public Works engineers, was scaled to size and superimposed on a mosaic of the aerial photographs of the area. (See Figure 2 in center fold.)

Careful scrutiny of Figure 2 is encouraging from the standpoint of the relocation problem. Only a small part of the land area to be flooded is not in woods. Also, the few small areas which appear to be cleared do not show evidence of recent cultivation or other use. Only one or two houses or other buildings can be seen within the area to be inundated, and none of these gives the appearance of being a dwelling place or of being regularly inhabited.

The conclusion derived from the study of the aerial photographs is that the problem of relocation would not be serious. At most it would involve only a very limited number of individuals or families, if indeed there were any permanent residents in the area to be flooded. Discussion of this problem with local knowledgeables confirmed the above conclusion. Those persons familiar with the area could not think of anyone permanently located within the limits of the area to be flooded. There was speculation that some hunters or fishermen might maintain camps in the locality, but there was no personal knowledge of such facilities.

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[7] See: Ted L. Napier and Cathy J. Wright, *An Evaluation of Forced Relocation Due to Rural Community Development* (Wooster, Ohio, Ohio Agricultural Research and Development Center, 1974).

In light of the above findings, and after drives around the proposed reservoir site, it can be safely predicted that there will be virtually no problem of relocation. This is an important discovery which relates directly to the economic and social cost estimates for the project. It is a very positive factor insofar as feasibility is concerned.

The Land Acquisition Problem

The matter of land acquisition, as noted, is also an important factor in the planning for a water resources development project. Although time and resources were not available for an extensive interview of landowners concerning their views about a project that would require selling or ceding some of their holdings, it was possible to determine certain facts that have a bearing on this type of decision making.

First and foremost, it was considered necessary to determine the number and classes of owners of land that might be covered by the reservoir. As a first step, the land ownership maps for Claiborne Parish on file in the State Land Office were consulted. Although these maps were considerably out of date, it was readily determined that the number of landowners to be affected by the flooding for the project was relatively small. Only approximately 50 holdings were identified. At this stage it was considered wise to consult local sources knowledgeable about owners in the area of the proposed reservoir. Fortunately for the study group, a person well acquainted with landownership in Claiborne Parish, Mr. George Tigner, agreed to compile a list of landowners whose land probably would be affected. Although it was stressed that his list was not officially checked out, it was felt by its author to be essentially correct. It is of importance that no more than 25 owners were identified by Mr. Tigner. It is also most significant that the U.S. Forest Service was determined to be the largest landowner to be affected. Roughly half of the shoreline of the proposed reservoir would be bounded by the Kisatchie National Forest (see Figure 3). The importance of federal ownership goes far beyond a matter of mere economics. Among other things, it suggests a certain level of development and maintenance. Said another way, multiple recreational uses, such as hunting and riding trails as well as camping sites, are in keeping with U.S. Forest recreation area tradition. Federal ownership also assures public access (vs. privately restricted access, which is an important criticism of Lake Claiborne).

A discovery that the number of landowners is small is also relevant. Although the counts made may not be completely accurate, they are enough so to assure that the problem would be minimal by comparison with the usual case. Further, it appears from data published by the Louisiana Forestry Commission that at least half of the owners have holdings of over 500 acres in size.[8] When large holdings are involved, owners are generally less reluctant to give up a part of their holdings.

Another indicator that the problem of land acquisition would not be too great is the fact that only woodland, primarily hardwood, is in-

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[8] Erin R. Gunter, *Forest Landownership in Louisiana,* 5th ed., (Baton Rouge, Louisiana, Louisiana Forestry Commission Bulletin No. 5, 1969) pp. 23-24.

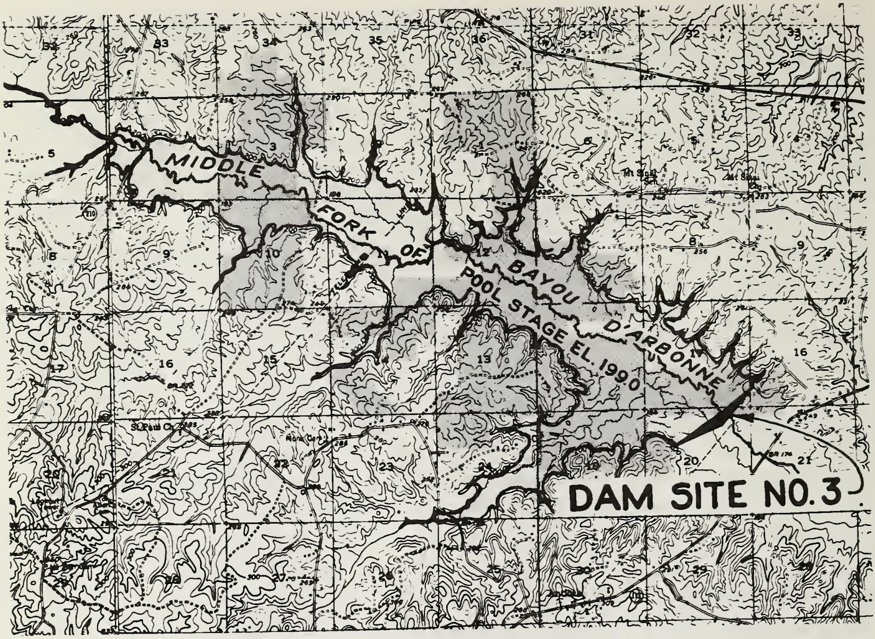

Figure 3.—Map showing extent of holdings by U.S. Forest Service in area of proposed reservoir.

volved. This type of cover is usually not too productive and thus does not represent a large investment loss. In actual fact, the proposed reservoir could well increase the value of land adjacent to it, enough to compensate owners for the worth of the land they might lose. This possibility was noted by one of the larger landholders in the affected area, who was interviewed as an influential. This man was an enthusiastic supporter of the project and felt that his neighbors and friends would be in favor of and support the action necessary for its implementation.

Again, the indicators available suggest that land acquisition problems would be minimal by comparison with other development of this general nature. The fact that most parish influentials are backing the project would obviously influence landholders who might otherwise be disinterested in selling or donating part of their holdings.

The Potential User Population

It seems appropriate to begin the discussion of the use potential of the proposed Middle Fork Bayou D'Arbonne Reservoir Project with a quotation which has relevance for development projects of all types. "Resources are not, they become."[9] This is but to emphasize that all a report such as this can do is to point out potentials; the realization of these potentials rests in the hands of those responsible for the design and management of the resource.

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[9] E. W. Zimmerman in H. L. Hunker, Ed., *Introduction to World Resources* (New York; Harper & Row, 1964), p. 21.

It is clear that the major use of the proposed reservoir would be for outdoor recreation. With this in mind, it is pertinent to note that there are three major evolving nationwide trends which have a direct causal association with increased demand for outdoor recreation. They are: (1) a growing and an urbanizing population; (2) an increasing amount of leisure time; and (3) a rapidly growing appreciation for the outdoors vs. the indoors. The latter has been identified as a "value" which derives from having to cope with a constant barrage of machines, vehicles, and other artifacts of city life and a relaxation of the so-called Protestant work ethic.[10]

The scope of what has been termed the "Leisure Boom" in the United States was outlined in an article in *U.S. News and World Report.* The author of the article noted that $105 billion was to be spent in 1972 by persons seeking a recreational experience. It is of interest to this report that water based activity, such as swimming, fishing, boating, and camping, ranked high in popularity.[11]

The above commentary on our emerging times indicates that the present social climate in the U.S. is such as to encourage, in fact to demand, outdoor recreation facilities. It is quite understandable why one of the growing concerns of the planners for the nation is the shortage of such facilities.[12]

In Louisiana, there is evidence from the recently developed Toledo Bend Reservoir that such facilities have a tremendous drawing power for outdoor recreationists. A user study conducted recently provided evidence that the reservoir attracted large numbers of users from cities as far away as 300 miles. The median distance traveled to get to Toledo Bend was approximately 150 miles.[13] The annual number of visitor days for this facility was estimated at 4½ million in its first years and was projected to reach 10 million after development of roads and other facilities.

The experience with Lake Claiborne in the parish (which is now overcrowded) provides evidence of the attraction that a lake can have. The specifics with regards to the economic benefits of the lake will appear in another report. However, the fact of its popularity and of its proven economic benefit to the parish has relevance for the proposed project.[14]

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[10] See: Alvin L. Bertrand and James G. Hoover, "Outdoor Recreation Facilities Appeal to Urban Users: The Toledo Bend Experience," paper read at Rocky Mountain Sociological Association meeting, El Paso, Texas, 1974.

[11] "Leisure Boom: Biggest Ever and Still Growing," *U.S. News and World Report,* Vol. LXXII, No. 16 (April 17, 1972), pp. 42-45.

[12] *A Program for Outdoor Recreation Research* (Report of Study Conference by the National Academy of Sciences for Bureau of Outdoor Recreation, U.S. Department of Interior, 1968), pp. 34-45.

[13] Alvin L. Bertrand and James G. Hoover, *Toledo Bend Reservoir: A Study of User Characteristics, Patterns, Preferences* (Baton Rouge, La., Louisiana Agricultural Experiment Station Bulletin No. 675, 1973).

With the appeal of outdoor recreational facilities as a given factor, the population base from which an outdoor recreation clientele might be drawn becomes critical. Toward shedding light on this variable, the number of people living within a given distance of the proposed dam site was estimated utilizing 1970 Census information.

It is both interesting and enlightening to discover that almost 75,000 persons live within 25 miles of the recommended site of the dam for the proposed reservoir. The territory covered by a 25-mile radius is shown as the smaller circle in Figure 4. In order of size the circles show the territory encompassed by a 50-, 75-, and 100-mile radius. As can be seen in Appendix B, some 619,764 persons live within 50 miles of the dam site, 1,003,851 live within 75 miles of the site, and well over 1½ million persons could get to the reservoir by driving no more than 100 miles.

The population base within 100 miles of the proposed reservoir is large enough to provide more than an adequate consumer market for the reservoir. In fact, despite the presence of two or three other relatively large lakes and reservoirs in the area, it is still logical to predict that there will be early and constant pressure on the reservoir by fishermen, boaters, and others interested in water recreation. The popularity of the reservoir will hold if fishing and other development can be maintained at reasonably satisfactory levels. There are three relatively large cities within 50 miles of the site—El Dorado, Arkansas, and Shreveport and Monroe, Louisiana. These centers of population are close enough to represent substantial numbers of potential users of an attractive outdoor recreation facility.

Other Relevant Social Impact Factors

Several other factors of a social impact nature have more or less direct relevance for the proposed "Middle Fork" project. Perhaps the most important of these is the relative underdevelopment of Louisiana with respect to outdoor recreation areas.

It is a dismal but true fact that Louisiana has not exploited its potential for outdoor recreation areas. The state ranks essentially last among the 50 states in per capita expenditures for parks and per capita expenditure for the acquisition of lands suitable for parks.[15]

Great strides have been made in the development of recreation areas in Louisiana within recent years, but there is still much to be desired. This fact is formally recognized in the Outdoor Recreation Plan recently released by the State Parks and Recreation Commission.[16] This plan outlines extensive outdoor recreational needs from 1975 to 1990

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[14] See report by Dr. James R. Michael, Louisiana Polytechnic University.

[15] See article in *State-Times* (Baton Rouge, La., August 3, 1974) entitled "State Parks Have Grown Despite National Ranking."

[16] *Outdoor Recreation in Louisiana, 1975-1980: State of Louisiana Outdoor Recreation Plan* (Baton Rouge, La., State Parks and Recreation Commission, 1974).

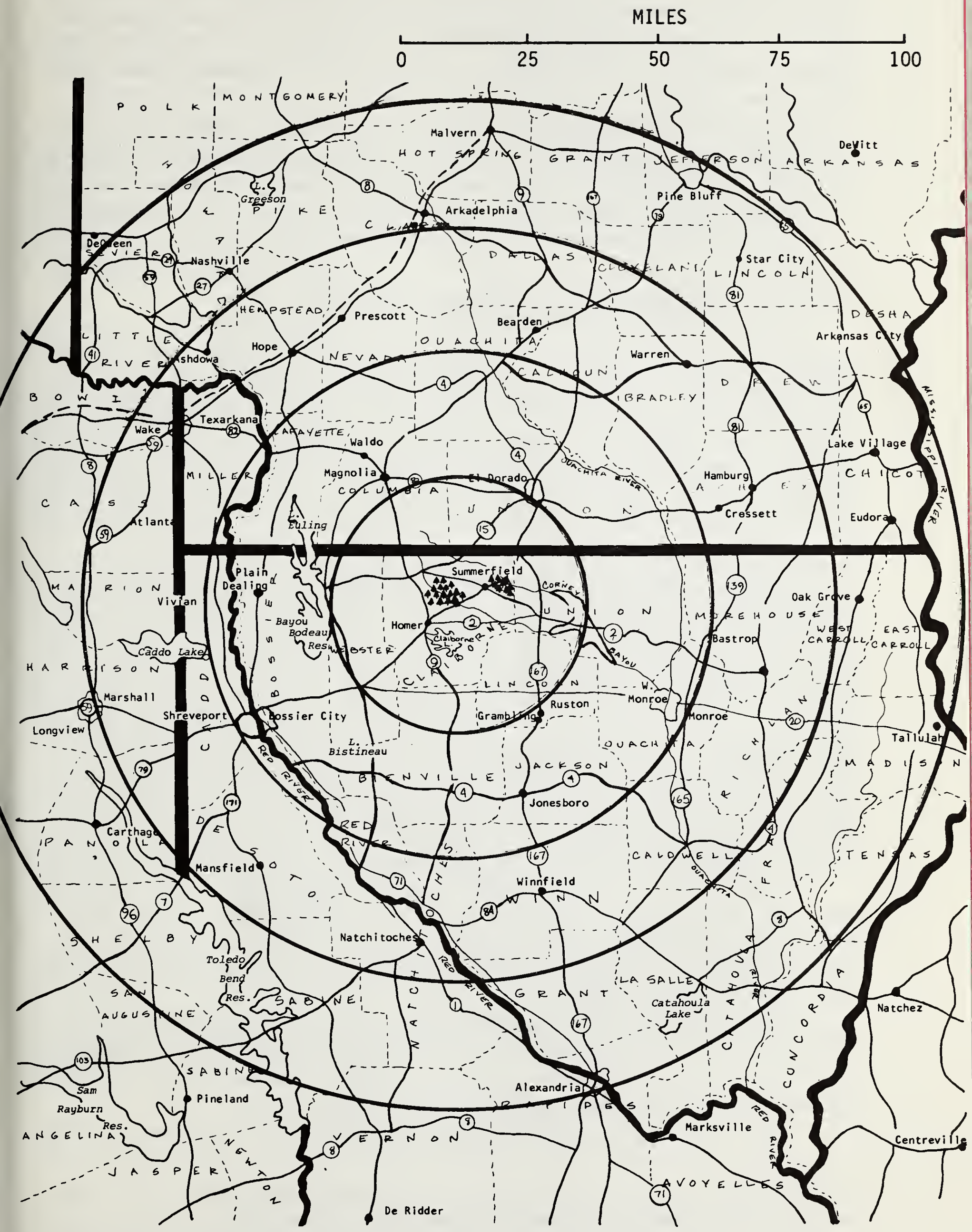

Figure 4.—Map showing area within 25, 50, 75, and 100 miles of proposed dam site.

and plans to alleviate these needs. A project, such as the proposed "Middle Fork" reservoir would most certainly be in keeping with these objectives. In fact, if the correct interpretation has been made, the proposed reservoir is the type of project that will be encouraged by the State Parks Bureau of Outdoor Recreation. According to the annual report (1974) of the State Parks and Recreation Commission:

> The goal of the budget unit (Bureau of Outdoor Recreation) is to obligate as near to 100 per cent of the federal apportioned funds as possible in each fiscal year to high quality outdoor recreation projects of state agencies and political subdivisions and thus increase the capacity of the state for outdoor recreational opportunity.

It suffices to note that the "Middle Fork" project, chiefly designed for recreation purposes, would contribute to such goals.

A second indirect social factor which has significance for the proposed project is the small percent of the area in Claiborne (1.7%) now devoted to reservoirs, lakes, rivers or streams. Only one parish (Lincoln) of the 10 which make up the Northwest planning district has less acreage devoted to such uses.[17] In this regard, it is significant that Claiborne includes almost 200,000 more acres within its bounds than does Lincoln. Claiborne Parish can thus be seen as somewhat underdeveloped insofar as its water resources are concerned. This, in itself, is an argument for a reservoir project in the parish.

There is a third factor which was considered of relevance to persons charged with making decisions relative to the proposed reservoir. This is the quality of development which has been maintained at Lake Claiborne. Persons who have studied lake and reservoir projects in the region judge the overall quality of the Lake Claiborne development as superior.[18] This superiority is attributed to the parish regulatory bodies, who imposed strict sanitation and other requirements on landowners and lake users. Visitors to Lake Claiborne have no difficulty in detecting that care has been taken in its development and upkeep. In this regard, it was determined that the appearance of the lake and the close regulation of its use is a matter of pride to its manager and to the people of the parish.

The point of the above is that it can be anticipated that the same care and pride will be manifested in the development of the "Middle Fork" lake. Good development practices will attract investors and users alike and assure maximum returns to the people of the parish, state, and nation for their investment.

A fourth factor which has implication for a project such as the one to which this study is addressed comes from a recent study of the impact of reservoirs on rural settlement patterns. Calvin L. Beale of the U.S. Department of Agriculture, who made the study, points out that:

The era of major dam building brought sizable reservoirs to most parts of the country and visibly affected rural settlement. For example, nonmetro counties in the South that contained parts of major reservoirs (50 or more square miles) increased in population by an average of 10 percent, well above that of the nonmetro South as a whole. They did so despite the fact that a number of dams are comparatively isolated in location.[19]

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[17] *Existing Land Use for Northwest Louisiana* (Shreveport, La., Coordinating and Development Council of Northwest Louisiana, May 1974.

[18] *Projected Ad Valorem Taxes Arising from the Development of the Toledo Bend Reservoir* (Ruston, La., Division of Business and Economic Research, Louisiana Polytechnic Institute, 1969), p. 19.

It can be anticipated from the above finding that the building of a second dam in Claiborne will increase the reservoir capacity in the parish to a size sufficient to attract settlement there. As noted previously, the development of Claiborne Parish is dependent upon keeping the present population in the parish and at the same time attracting new residents.

Conclusions and Recommendations

Study of the factual materials presented in this report leads to several basic conclusions. The first is that Claiborne Parish is in need of development projects of one type or another if it is to stem the flow of its younger, better educated and more vigorous residents to other regions. Such projects are needed not only to improve the opportunity structure within the parish, but to maintain and better the levels of living which exist therein.

The second conclusion which is readily apparent from the investigation conducted is that the people of Claiborne Parish are anxious and willing to promote and support projects that will increase the prosperity of and upgrade the quality of life in the parish. In a specific sense they are in near full support of the Middle Fork Bayou D'Arbonne Reservoir Project, which is seen as a potential economic boost to the area as well as a source of enjoyment for many persons.

A third conclusion evident from the research is that the proposed reservoir project will not entail exceptional cost, in either an economic or a social sense. Several factors are relevant here, including the large amount of federally owned land, the lack of intensively developed lands, the fact that relocation will not be a problem, and the fact that property acquisition will not involve a large number of holders.

The above findings lead to a final conclusion. This is that the proposed Middle Fork Bayou D'Arbonne Reservoir Project is, from a social impact point of view, not only feasible but recommended. It has a high potential as a low cost, high benefit development project and is in keeping with the goals and objectives of rural and outdoor recreation development of the state and nation.

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[19] Calvin L. Beale, "Rural Development: Population and Settlement Prospects," *Journal of Soil and Water Conservation*, Vol. 29, No. 1 (January-February, 1974), p. 26.

APPENDIX A

INTERVIEW GUIDE:

Study of Attitudes and Opinions Relative to Proposed Middle Fork Bayou D'Arbonne Reservoir Project, Claiborne Parish, La. (Interview Guide for use in the Interview of Influentials and Knowledgeables)

Questions: (Answers to be taped or recorded on separate sheet)

I. You are, of course, acquainted with Lake Claiborne.

   a. Have you used the lake? If yes, in what manner? (Probe for frequency and types of use)

   b. If you have not used the lake personally, have you discussed the lake with persons who have used it? What is the general reaction of persons who use the lake?

II. What is your evaluation of Lake Claiborne? (Probe for specific illustrations as well as general observations relative to positive and/or negative impact)

III. You are aware, no doubt, of the proposal for a second lake to be made by damming the Middle Fork of Bayou D'Arbonne. What is your overall feeling about such a project?

   a. List specific types of benefits which you anticipate for the parish.
   b. List specific types of problems which you anticipate for the parish, if any.

IV. Have you discussed the project with others in your community or parish?

If yes, what is the general sentiment of the persons with whom you have discussed the project?

V. Sometimes it is necessary for local groups to raise matching funds and to assure the provision of services such as roads and utilities before funding can be obtained from state or federal sources. Do you feel that the leaders of the parish would be willing to commit themselves in this manner for the proposed reservoir? Would you personally support such action on the part of your parish leaders?

VI. Any other comment you wish to make regarding the proposed reservoir project would be appreciated.

Personal Data Information:

Interviewee: Name: ________________________________
Address: ________________________________
Open Country Residence: ____________________

1. Length of residence in Claiborne Parish: ______________ If less than 10 years, previous place of residence: ______________________
2. Occupation and/or position: ________________________________
3. Affiliation and offices of a civic and/or public agency nature:
____
4. Membership in other organizations: List
________________________________ Officer? (Past or Present) ______
________________________________ ______
5. Date of birth: ______________________

6. Highest educational attainment: ______________________________

7. Marital status: ______________________________

8. If married, number _____ and age of children: ______________________________

9. Family income: (Please check appropriate blank)

$1— 999________
1,000— 1,999________
2,000— 2,999________
3,000— 3,999________
4,000— 4,999________
5,000— 5,999________
6,000— 6,999________
7,000— 7,999________
8,000— 8,999________
9,000— 9,999________
10,000—11,999________
12,000—14,999________
15,000—24,999________
25,000 + ________

Date: ______________ Interviewer: ______________________

APPENDIX B

Population Distribution Within 25, 50, 75, and 100 Miles of Proposed Middle Fork Bayou D'Arbonne Dam Site

Population Distribution Within 25 Miles

ARKANSAS	
Columbia County:	
Emerson Township	2,252
Union County:	
Garner, El Dorado, Jackson, Cornie, Tubal, Wesson, Henderson (Junction City) Townships	32,871
LOUISIANA	
Union Parish:	
Wards 3, 4, 10	5,971
Lincoln Parish:	
Wards 2, 3, 6, 7, 8	6,187
Claiborne Parish:	17,024
Bienville Parish:	
Wards 1, 2	6,873
Webster Parish:	
Ward 1	2,014
TOTAL POPULATION WITHIN 25 MILES:	73,192

Population Distribution Within 50 Miles

ARKANSAS	
Union County:	45,428
Columbia County:	25,952
Lafayette County:	10,018
Miller County:	
Red River, Cut Off Townships	1,016
Nevada County:	
Albany, Caney, Jackson, Parker, Alabama, Taylor, Leake Townships	3,083
Ouachita County:	
Valley, River, Bradley, Liberty, Bragg, Ecore, Jefferson, Marion, Lafayette, Smackouer, Bridge Creek, Washington Townships	26,910
Calhoun County:	
River, Polk, Dallas, Jackson, Franklin, Champagnolle, Fayette Townships	3,730
Bradley County:	
Sumpter, Ouachita, Washington, Eagle, River Townships	1,927
Ashley County:	
Egypt, Marie Saline Townships	12,144
LOUISIANA	
Claiborne Parish:	17,024
Union Parish:	18,447
Lincoln Parish:	33,800
Jackson Parish:	15,963
Bienville Parish:	16,024
Bossier Parish:	64,519
Webster Parish:	39,939
Caddo Parish:	
Wards 9, 1, 4, 3, 8	194,575
Red River Parish:	
Wards 2, 3, 4, 7, 8	3,086
Natchitoches Parish:	
Ashland, Goldonna	548
Winn Parish:	
Wards 4, 10	1,083
Ouachita Parish:	
Wards 1, 5, 6, 7, 8, 9, 10	82,985

(Continued)

Population Distribution Within 50 Miles (continued)

LOUISIANA (continued)

Morehouse Parish:	
Wards 1, 2	1,563
TOTAL POPULATION WITHIN 50 MILES:	619,764

Population Distribution Within 75 Miles

ARKANSAS

Union County:	45,428
Columbia County:	25,952
Lafayette County:	10,018
Miller County:	33,385
Nevada County:	10,111
Ouachita County:	30,896
Calhoun County:	5,573
Bradley County:	12,778
Ashley County:	
Longview, White, Bearhouse, Banner, Prairie, Carter, Mill Creek, Egypt, Marie Saline, Elon, Extra, Beech Creek, Wilmot Townships	21,148
Drew County:	
Saline, Crook, Veasey, Bearhouse Townships	2,442
Cleveland County:	
Kingsland, Redland, Lee, Hurrican, Harper Townships	2,896
Dallas County:	
Manchester, Nix, Princeton, Bunn, Liberty, Southall, Owen, Holly Springs, Jackson, Fordyce, Dry Run Townships	8,892
Clark County:	
Gum Springs, Oklona, Missouri Township	5,201
Pike County:	
Wolf Creek Township	666
Howard County:	
Blackland, Saratoga Townships	853
Sevier County:	
Paraloma	60
Hempstead County:	
Wallaceburg, Ozan, Saline, Garland, Noland, Bois d'Arc, Water Creek, De Roane, Spring Hill, Bodcaw Townships	17,724
Little River County:	
Red River, Cleveland, Franklin, Jefferson, Johnson Townships	6,725

LOUISIANA

Caddo Parish:	230,184
Bossier Parish:	64,519
Webster Parish:	39,939
Claiborne Parish:	17,024
Union Parish:	18,447
Morehouse Parish:	32,463
Lincoln Parish:	33,800
De Soto Parish:	22,764
Red River Parish:	9,226
Bienville Parish:	16,624
Jackson Parish:	15,963
Ouachita Parish:	115,387
Richland Parish:	21,774
Caldwell Parish:	9,354
Winn Parish:	16,369
Sabine Parish:	
Ward 7	1,473
Natchitoches Parish:	
Ward 2	5,701
Grant Parish:	
Wards 2, 4, 5	3,659
La Salle Parish:	
Ward 2	3,909

(Continued)

Population Distribution Within 75 Miles (continued)

LOUISIANA (continued)

Franklin Parish:	2,806
Wards 6, 8	4,000
West Carroll Parish (⅓):	
TEXAS	
Bowie County:	48,899
Hooks, Leary, Texarkana Division, Maud	
Cass County:	11,950
Queen City-Bloomburg, Atlanta, Blvins McLeod Divisions	8,517
Marion County:	
Harrison County:	5,204
Karnack, Waskom Division	
Panola County:	3,148
De Berry-Deadwood Division	
TOTAL POPULATION WITHIN 75 MILES:	1,003,851

Population Distribution Within 100 Miles

ARKANSAS	33,385
Miller County:	10,018
Lafayette County:	25,952
Columbia County:	45,428
Union County:	24,976
Ashley County:	18,164
Chicot County:	15,157
Drew County:	12,778
Bradley County:	5,573
Calhoun County:	30,896
Ouachita County:	10,111
Nevada County:	19,308
Hempstead County:	11,194
Little River County:	8,711
Pike County:	21,537
Clark County:	21,963
Hot Spring County:	10,022
Dallas County:	9,711
Grant County:	6,605
Cleveland County:	
Sevier County:	
Buckhorn, Bear Creek, Saline, Clear Creek, Red Colony	9,554
Paraclifta, Ben Lomond, Washington Townships	
Howard County:	
Clay, Blue Ridge, Madison, Holly Creek, Muddy Fork, Brewer,	
Center Point, Nashville, County Line, Saline, Dillard, Blue Bayou,	
Mineral Springs, Buck Range, Franklin, Blackland,	10,712
Saratoga Townships	
Montgomery County:	615
Walnut, Caney Townships	
Garland County:	3,418
Mazarn, Mill, Antioch Townships	
Jefferson County:	
Pine Bluff, Washington, Niven, Victoria, Melton, Spring,	71,687
Talladega, Richland Townships	
Lincoln County:	
Spring, Bartholomew, Wells Bayou, Crane Creek, Owen, Smith,	8,095
Long Pine, Mill Creek Townships	
Desha County:	
Randolph, Walnut Lake, Jefferson, Richland, Clayton, Franklin,	15,817
Halley, Bowie Townships	
LOUISIANA	12,884
East Carroll Parish:	13,028
West Carroll Parish:	

Continued)

Population Distribution Within 100 Miles (continued)

LOUISIANA (continued)

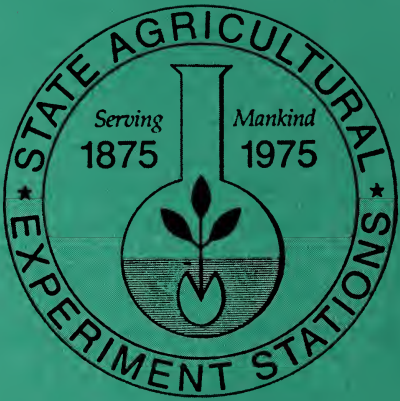
Morehouse Parish:	32,463
Union Parish:	18,447
Claiborne Parish:	17,024
Webster Parish:	39,939
Bossier Parish:	64,519
Caddo Parish:	230,184
De Soto Parish:	22,764
Red River Parish:	9,226
Bienville Parish:	16,024
Lincoln Parish:	33,800
Jackson Parish:	15,963
Ouachita Parish:	115,387
Richland Parish:	21,774
Franklin Parish:	23,946
Caldwell Parish:	9,354
Winn Parish:	16,369
Grant Parish:	13,671
Natchitoches Parish:	35,219
Sabine Parish:	18,638
Madison Parish:	
Wards 3, 4, 5, 6, 7, 8	13,884
Tensas Parish:	
Wards 2, 4, 5, 7	4,004
Concordia Parish:	
Wards 3, 4	3,885
Catahoula Parish:	
Wards 1, 2, 3, 4, 5, 6	10,464
La Salle Parish:	
Wards 1, 2, 3, 4, 5, 6, 7, 8	13,047
Rapides Parish:	
Wards 7, 8, 9, 10	43,723
Vernon Parish:	
Wards 2, 6	5,031

MISSISSIPPI

Claiborne County:	
Districts 1, 2	7,072
Warren County:	
Districts 2, 3, 4, 5	35,154
Issaquena County:	
Districts 2, 3, 4, 5	2,249
Bolivar County:	
Districts 1, 2	11,927
Washington County:	
Districts 1, 2, 3	52,557

TEXAS

Cass County:	24,133
Bowie County:	
New Boston, Hooks, Texarkana, Maud-Elliott Creek Divisions	60,144
Harrison County	44,841
Marion County:	8,517
Panola County:	15,894
Rusk County:	
Tatum, Pine Hill, Overton, Mount Enterprise Divisions	9,887
Shelby County:	19,672
San Augustine County:	
San Augustine	2,539
Sabine County:	
Milam Division	1,502
TOTAL POPULATION WITHIN 100 MILES:	1,632,136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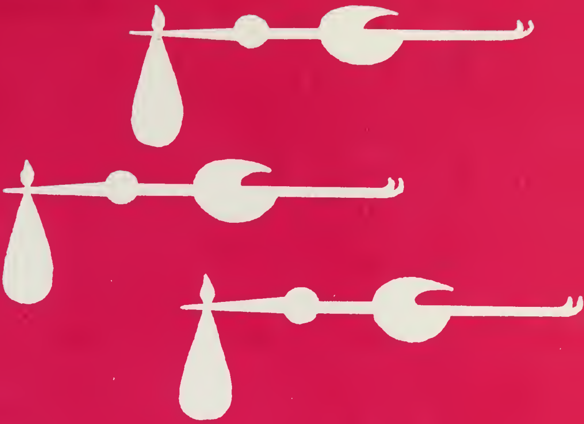
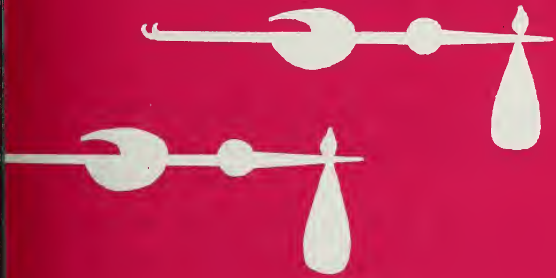


BIRTH RATES IN LOUISIANA In the Post-Baby Boom Era



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Maisy L. Cheng

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AGRICULTURAL EXPERIMENT STATION
DOYLE CHAMBERS, DIRECTOR

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Birth Rates in Louisiana In the Post-Baby Boom Era

THOMAS KOEBERNICK AND MAISY CHENG*

Objectives

The purpose of this research was to examine changes in fertility among Louisiana women from 1960 to 1970. Specifically, the objectives were to look at fertility changes and the influence of selected variables upon these changes. We looked at the fertility of the total population of the state, as well as each parish population. The effects of several social, economic, and demographic variables were assessed. At the parish level, we sought to determine how our variables affected fertility variations among parishes in 1960 and 1970 and whether each characteristic influenced fertility to the same degree for both years. The contribution made by each variable to the total variation of parish fertility was also studied. As the data will demonstrate, fertility in Louisiana has followed the pattern of decline that has been occurring in the nation and the South. However, as shown in Table 1, Louisiana's fertility has consistently remained higher than that of the nation and the Southern region.

Table 1.—Children Ever Born per 1,000 Ever Married Women 15 to 44 Years Old, for the United States, the South, and Louisiana, 1910 to 1970

	1910	1940	1950	1960	1970
United States	2,788	1,899	1,859	2,314	2,357
South	3,039	1,886	2,037	2,407	2,341
Louisiana	3,474	2,193	2,087	2,692	2,655

Source: U.S. Bureau of the Census, *Census of Population, 1940. Differential Fertility 1940 and 1910: Fertility for States and Large Cities; Census of Population: 1950,* Vol. 4, Part 5, *Fertility; Census of Population, 1960,* Vol. 1, Part 20, *Louisiana,* and Vol. 2, *Women by Number of Children Ever Born; Census of Population, 1970,* Vol. 1, Part 20, *Louisiana,* and Vol. 2, *Women by Number of Children Ever Born.*

Data and Methodology

Measures of Fertility

Fertility refers to the incidence of childbearing among women of a population over some period of time. In the United States we have two major sources for statistics on fertility. There is the birth registration system carried out by each state and there is the information collected by the Bureau of the Census. Birth registration information is collected continuously every day, but usually these statistics are reported annually. Every ten years the Census Bureau gathers additional information on fertility in the Decennial Census.

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*Former Assistant Professor and Graduate Assistant, respectively, Department of Sociology and Rural Sociology, Louisiana State University.

Birth registration data allow us to compute crude birth rates, and rates for specific ages and races. These rates are exact statements of the number of births by the selected characteristic for any one year. That is, this information tells us what the current fertility behavior of the population is. Another way to assess current fertility is to compute a child-woman ratio from a decennial census. This ratio (number of children under five/number of women 15 to 49 years old) approximates the fertility behavior of women during the five-year period prior to the census. If we want to examine the cumulative fertility of women, there is census information on the total number of children ever born to women (i.e., the CEB rate). Usually this CEB rate is restricted to women in the 15 to 44 age group. The age range 15 to 44 or 49 is used because it is during this period that women are capable of bearing children. We want to see just how many children they actually do have. Often eligible women are further divided into even smaller age groups, since we know that childbearing is not equally distributed over the entire period of a female fecundity. The measures we have mentioned are also often computed for only ever married women rather than all women since the overwhelming number of births occur among this group, particularly at the younger ages.[1]

When faced with such a diversity of measures the demographer, as well as the layman, has to decide which ones are best for the purposes of his analysis. In this report we have chosen the measure that is best suited to describe the aspect of Louisiana's fertility being discussed. Often, the choice is simplified by the fact that only one of the measures is available.

Methodology

The first section of this report is descriptive. We provide a picture of Louisiana's fertility changes, using information from the U.S. Census and the Louisiana Bureau of Vital Statistics. In our analysis of parish fertility we examine the statistical relationship between parish child-woman ratios and ten social, economic, and demographic characteristics of parish populations. First, we see how strongly each separate variable is correlated with parish fertility, using simple (zero-order) correlations. Then we use the statistical method of multiple regression analysis.[2] This method allows us to determine the effect of all ten variables at the same time. We can then determine how important each one is relative to the other nine in explaining parish fertility variations. Parish fertility in 1960 and 1970 is analyzed separately and then compared. This procedure permits us to determine whether there have been any changes in the relationship of our ten independent variables to fertility from 1960 to 1970.

---

[1] Recent evidence indicates that illegitimate births are rising in Louisiana as well as nationally. In 1969, 142 out of every 1,000 births were illegitimate. The rate of the youngest age group, 15 to 19, has increased the greatest amount. Over one-half of the births occurring to Negro women in this age group were illegitimate in 1972. However, this increase seems to be not so much an increase in the number of such births, which have remained constant proportionally to the size of this population, but rather is a product of the decreasing number of total births occurring in this age group. Note that the child-woman ratio for all women married and unmarried still decreased substantially from 1960 to 1970.

Changes in Fertility, 1960 to 1970

There was a considerable decline in the fertility of Louisiana women from 1960 to 1970. The 1970 crude birth rate (total number of births/total population X 1,000) was 20.5 compared with a rate of 27.7 in 1960. Only the birth rates during the Depression have been lower, 18.0 for the year 1934. A similar decline in the fertility rate (number of births/females 15 to 44 years of age X 1,000) occurred from 1960 (136.6) to 1970 (97.4). As shown in Table 2, census data for CEB and the child-woman ratio also indicate declining fertility over the decade. Another point made in the table is that the decrease in fertility is least for married women. Interestingly, the decline in cumulative fertility (CEB) is small compared with that of current fertility (the child-woman ratio).

Table 2.—The Rates of Children Ever Born and the Child-Woman Ratios by Marital Status of Women for 1960 and 1970

	CEB		Child-Woman Ratio	
Year and Percentage Change	All Women 15 to 44 Years	Ever Married Women 15 to 44 Years	All Women 15 to 49 Years	Ever Married Women 15 to 49 Years
1960	2,032	2,692	562	720
1970	1,820	2,655	401	561
% Change, 1960 to 1970	–10.4%	–1.4%	–28.6%	–22.1%

Source: U.S. Bureau of the Census, *Census of Population,* Vol. 1, Part 20, *Louisiana,* Tables 37, 51 (1960); Tables 48, 52 (1970).

Cumulative Fertility

Why has there been such a small decline in CEB for ever married women? An answer can be found by examining Figure 1. When women are compared by age for 1960 and 1970, we see that the fertility of the younger aged women has declined. However, women 35 to 44 years of age in 1970 had borne more children than had women of this age in 1960. The decreases in the younger age groups were offset by the increase in the oldest group. The CEB for the oldest age group closely approximates the completed fertility of these women, since the birth rate after age 35 is quite low.

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[2] See Figure A-2 in the Appendix for the multiple regression equation that is used.

Figure 1 offers an excellent illustration of how social and economic conditions affect fertility, making it subject to sizable variations over time. Consider that women 35 to 44 in 1960 were entering their childbearing years during the Depression and World War II, periods of low fertility in our nation's history. Women in this age group in 1970 had a totally different set of social and economic conditions during their early childbearing years in the late 1940's and the fifties. It was a period of prosperity and peace. Given these conditions and that many women had postponed childbearing in the earlier period, the United States experienced the Postwar Baby Boom. Now in a time of economic stagnation and awareness of world overpopulation, fertility is again declining. If the present trend continues through 1980, we should see a sizable decline in the CEB rate for Louisiana by that time.

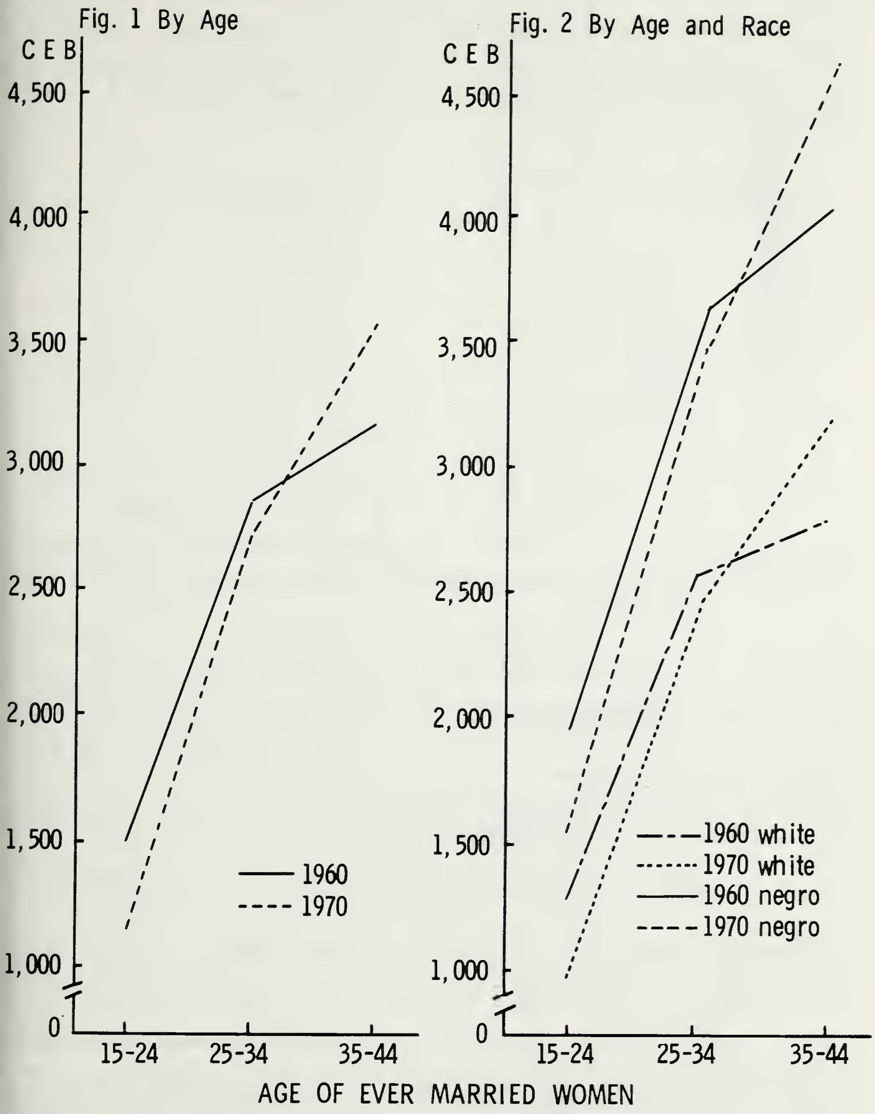
Race Differentials

It is interesting that in Figure 2 we can observe identical patterns of change in the CEB rates of ever married white and Negro women. There are declines at the younger ages and an increase in the oldest age group. However, Negro women in this age group appear to have been more vigorous participants in the Baby Boom than their white counterparts. Consequently, the difference between the white and Negro ever married CEB rates from 1960 to 1970 actually increased from 1,051 to 1,059. However, the differences between the races for the CEB rate based on all women 15 to 44, as well as the child-woman ratio for all women and ever married women only, decreased. The decrease reflects the effects of the increase in the number of women in the younger ages together with their decreased fertility levels. This trend of declining fertility is further supported by the age-specific birth rates for Louisiana. These rates, shown in Figure 3, declined from 1960 to 1970 for every age group regardless of race. One can see that the most dramatic declines occurred at the younger ages.

In the United States, Negro fertility historically has been higher than white fertility.[3] This is still true, especially in the South. Much of this difference appears to be a product of the socio-economic char-

---

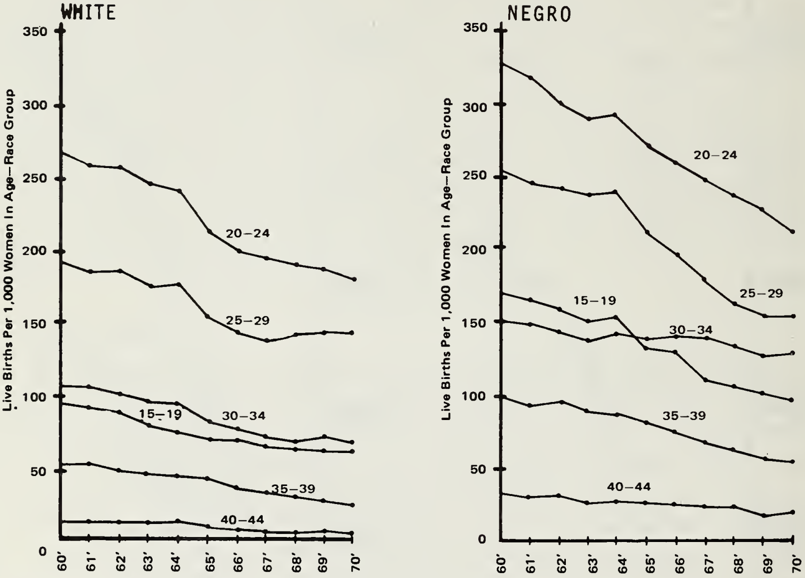
[3] Historically, the U.S. Bureau of the Census has utilized the terms "white" and "nonwhite" when using race as a variable. The separation of Negroes from the more inclusive category, nonwhite, has received wider application in Census publications for 1970 than in any previous census year. In order to avoid confusing the reader, we have consistently used Negro instead of nonwhite even though most of the 1960 data is presented for whites and nonwhites. Negroes constituted 99.4% of all nonwhites in Louisiana in 1960.



Source: U. S. Bureau of the Census, Census of Population, Vol. 1, Part 20, Louisiana, Table 51 (1960), Table 52 (1970)

Figures 1 and 2.—Children Ever Born per 1,000 Ever Married Women, 1960 and 1970.

acteristics of the two races. Data from the 1970 Census allows us to examine the effects of a few of these characteristics upon the fertility of the white and Negro populations. When we compare the number of children ever born for ever married white and Negro women and introduce level of education of the mother, her labor force status, and the occupation and income of the father, some interesting patterns emerge.



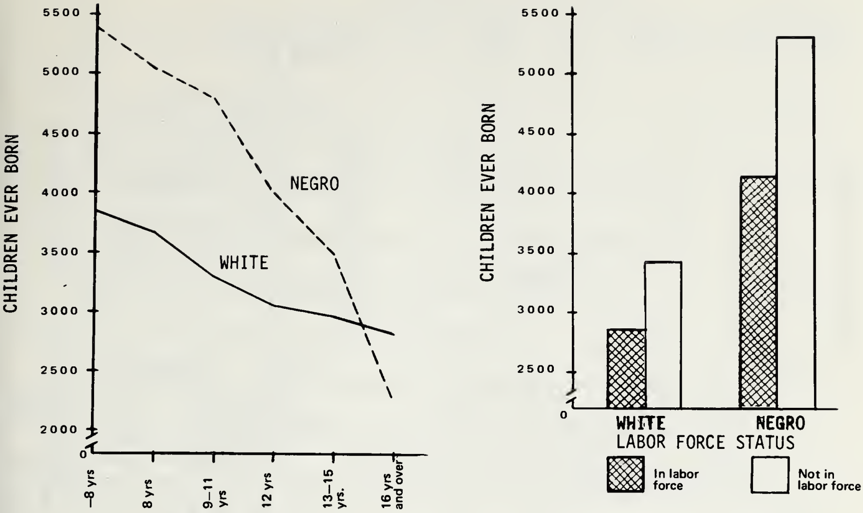
* All population estimates used in calculating the above rates were provided by the Research Division of Louisiana Tech University, College of Administration and Business.

Source: Louisiana State Department of Health, Statistical Report of the Bureau of Vital Statistics, 1972, Fig. 1, p.7.

Figure 3.—Age-Specific Birth Rates by Race, 1960-1970.

Figure 4a shows that the difference between white and Negro fertility in 1970 is greatest among the least educated. As both races become better educated their fertility becomes more similar. Fertility among college educated Negro women is even lower than among their white counterparts! Another factor influencing fertility is whether or not a woman is in the labor force. Participants in the labor force have fewer children. The difference between participants and nonparticipants is greatest for Negroes.

While husband's occupation has a clear association with the number of children ever born, for both groups, Figure 4b reveals that the greatest fluctuation occurs among Negroes. The occupation with highest fertility is the farm laborer and foreman category. However, for Negroes the second most fertile group is that of farmers and farm managers, but



Source: U.S. Bureau of the Census, Census of Population, Vol. 1, Part 20, Louisiana, 1970, Table 162.

Figure 4a.—Children Ever Born per 1,000 Ever Married Women 35-44 Years Old by Race and Wife's Education and Employment Status, 1970.

for whites it is the laborer (nonfarm) category. As we move up the occupational hierarchy fertility levels move towards convergence, as is the case with education. Negro managers, proprietors, administrators, and professionals and technical workers have a lower fertility than whites in similar occupations. One point suggested by this figure is that rural residence has a much stronger positive effect on Negro fertility than it does on white fertility. Interestingly, when we look at the incomes of husbands in Figure 4b, we find that there is no reversal between Negroes and whites at the upper end of the income scale such as we find for education and occupation. Still, the same pattern of decline exists for both groups, with high income being associated with low fertility.

Place of Residence Differentials

A person may reside in a metropolitan parish or a nonmetropolitan parish depending on whether or not the parish is a part of a Standard Metropolitan Statistical Area. Louisiana has six SMSA's which are comprised of ten parishes.[4] Also, an individual may reside in an urban place of residence (a place with a population of 2,500 or more) or in a rural place having less than 2,500 residents. People living in rural areas are

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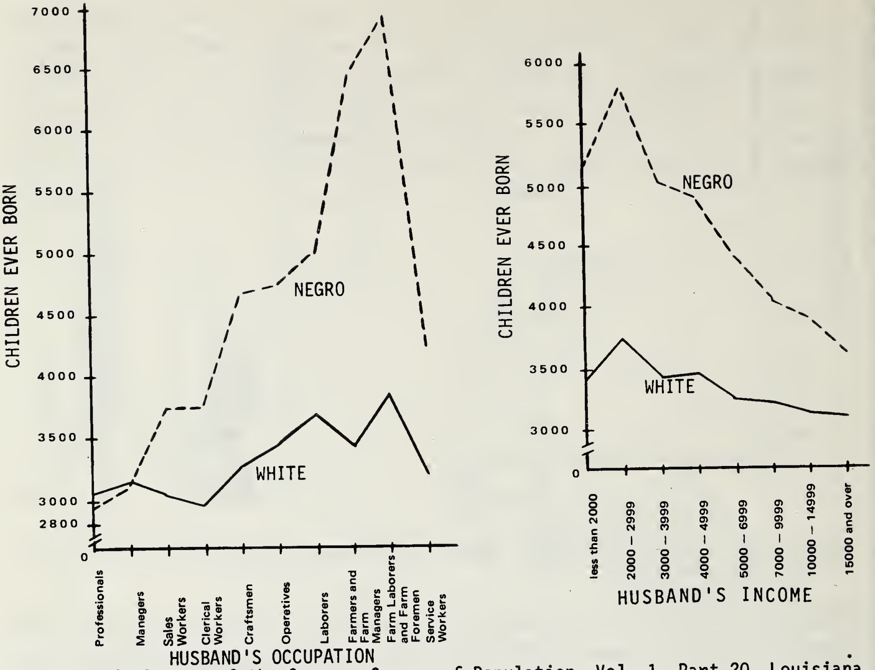
[4] The metropolitan parishes are as follows: Bossier, Caddo, Calcasieu, East Baton Rouge, Jefferson, Lafayette, Orleans, Ouachita, St. Bernard, and St. Tammany.

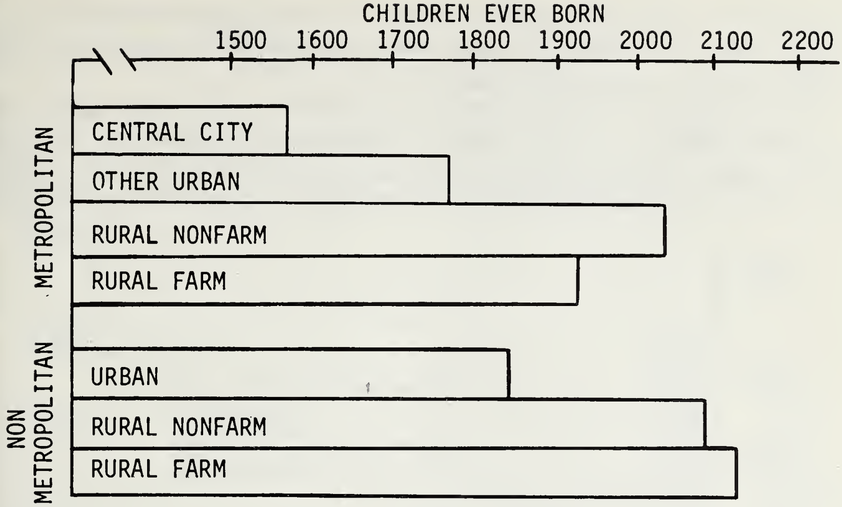


Source: U.S. Bureau of the Census, Census of Population, Vol. 1, Part 20, Louisiana, 1970, Table 162

Figure 4b.—Children Ever Born per 1,000 Ever Married Women 35-44 Years Old by Race and Husband's Occupation and Income, 1970.

further categorized into those living on a farm versus those living in a small village, town, or the open-country. Fertility is lower in metropolitan areas than in nonmetropolitan ones. The CEB rate for ever married women living in metropolitan parishes is 2,483 for 1970, versus 2,886 for nonmetropolitan residents. As Figure 5 for 1970 indicates, there are sizable differences among metropolitan and nonmetropolitan residents when the urban-rural classification is introduced. Urban residents have lower fertility than rural ones. Urban metropolitan residents have lower fertility than urban nonmetropolitan residents, and rural metropolitan residents have lower fertility than rural nonmetropolitan residents. Surprisingly, the rural farm metropolitan resident has the lowest fertility of all four rural categories.

When age is introduced into this classification scheme in Figure 6 some interesting variations occur. Notice the relatively undifferentiated fertility of the youngest age group (15-24 years). The major difference between this age group and the older ones can be seen in the relatively high fertility of the metropolitan farm population. For the next oldest age group (25-34 years) there appear to be three distinct fertility levels.



Source: U.S. Bureau of the Census, Census of Population, Vol.1, Part 20, Louisiana, 1970, Table 74.

Figure 5.—Children Ever Born per 1,000 Total Women 15-44 Years Old by Metropolitan and Nonmetropolitan Residence, 1970.

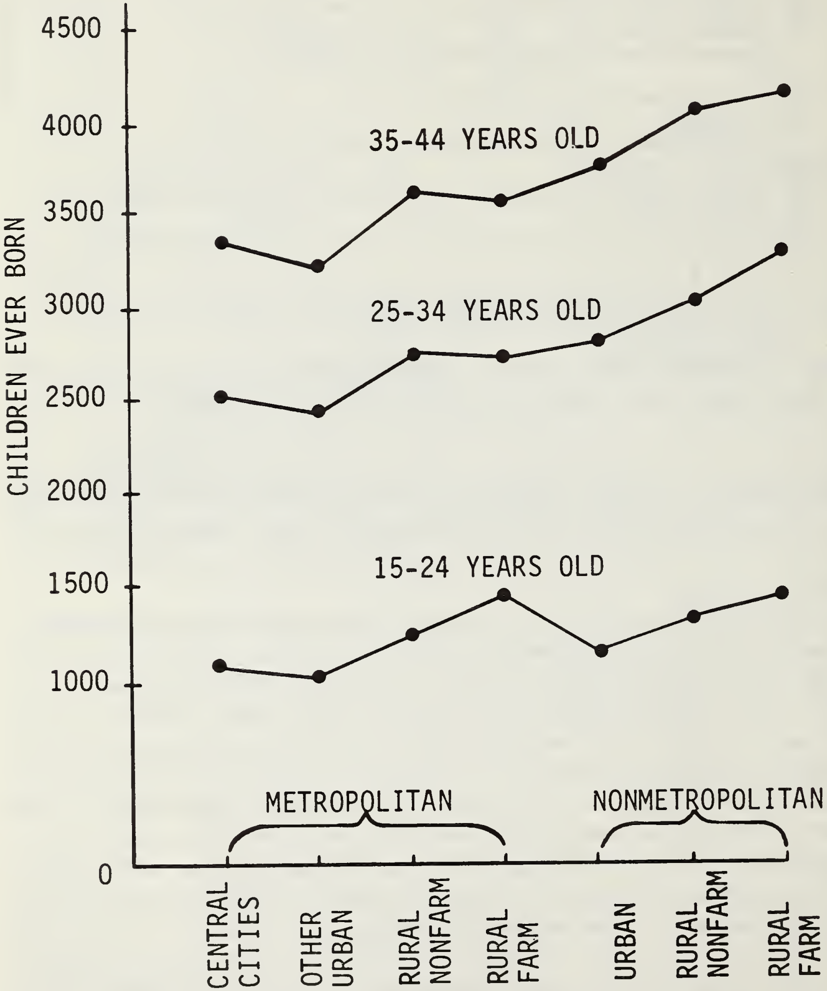
The lowest level is occupied by urban metropolitan residents. In the middle one are the rural farm and nonfarm metropolitan residents and urban nonmetropolitan ones. Nonmetropolitan farm and nonfarm residents are at the highest level. The same pattern can be observed for the oldest age group.

Unfortunately there are no computed data on the 1960 metropolitan-nonmetropolitan populations. So for comparative purposes we must restrict ourselves to the data on rural and urban residence. Looking at Figure 7 we see that there has been relatively little change in the children ever born rates of urban and rural farm populations of ever married women whether white or Negro. A very small increase occurred in the urban fertility of each group and an equally slight decrease occurred in fertility for each rural nonfarm group. However, there was a sizable decrease in the rural farm fertility for both groups. Still, Negro fertility was greater for each residential category, though the size of the difference lessened as the population became less rural.

Combining age, race, and place of residence in Table 3 gives a good picture of how fertility varies according to these characteristics. For both racial groups, fertility is always lowest at the youngest ages for each residence category, and highest at the oldest ages. For 1970, we see that in each age group whites have lower fertility than Negroes. Also, urban residents have lower fertility than rural nonfarm ones, who have lower fertility than rural farm residents for each racial group.

Examination of the 1970 CEB for women 35 to 44 shows that the average urban white woman had borne 3.1 children while the average rural farm Negro woman had borne 6.4 children.

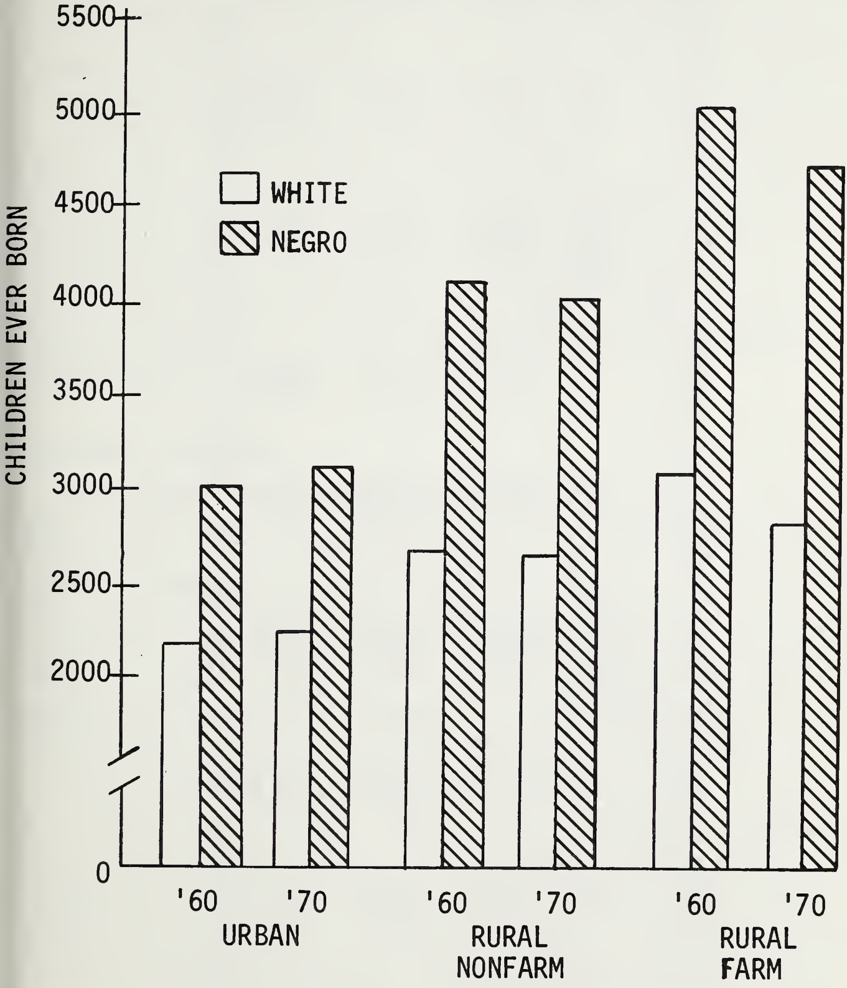
Comparing the absolute differences between Negro and white fertility in Table 3, we find that the differences decreased for all categories except for urban and rural nonfarm women 35 to 44 years of age. The difference between CEB rates for women 35 to 44 increased by



Source: U.S. Bureau of the Census, Census of Population, Vol. 1, Part 20, Louisiana, 1970, Table 74

Figure 6.—Children Ever Born per 1,000 Ever Married Women 15-44 Years Old by Residence and Age, 1970.

44.4% for urban dwellers and by 15.4% among rural nonfarm residents. Sizable decreases in white-Negro differences are found for rural farm 15 to 24 year olds (—27.8%), urban 15 to 24 year olds (—18.5%), and rural nonfarm 25 to 34 year olds (—13.1%). All other categories had decreases of 5% or less. The overall consequence of these fertility changes was that the total change in difference between Negro-white CEB rates for ever married women from 1960 to 1970 was less than 1%.



Source: U.S. Bureau of the Census, Census of Population, Vol. 1, Part 20, Louisiana, Table 51(1960); Table 52(1970)

Figure 7.—Children Ever Born per 1,000 Ever Married Women 15-44 Years Old by Race and Residence, 1960 and 1970.

Table 3.—Children Ever Born per 1,000 Ever Married Women by Race, Age, and Residence for 1960 and 1970

Race and Residence	15 to 24 Years Old			25 to 34 Years Old			35 to 44 Years Old		
	1960	1970	% Change, 1960-1970	1960	1970	% Change, 1960-1970	1960	1970	% Change, 1960-1970
Urban									
White	1,225	914	—25.4%	2,407	2,331	—3.2%	2,553	3,062	+19.9%
Negro	1,895	1,460	—23.0%	3,327	3,216	—3.3%	3,402	4,288	+26.0%
CEB Difference	670	546	—18.5%	920	885	—3.8%	849	1,226	+44.4%
Rural Nonfarm									
White	1,473	1,149	—22.0%	2,849	2,727	—4.3%	3,311	3,479	+5.1%
Negro	2,122	1,783	—16.0%	4,284	3,974	—7.2%	5,109	5,554	+8.7%
CEB Difference	649	634	—2.3%	1,435	1,247	—13.1%	1,798	2,075	+15.4%
Rural Farm									
White	1,442	1,304	—9.6%	3,087	2,887	—6.5%	3,613	3,525	—2.4%
Negro	2,302	1,933	—16.0%	4,871	4,649	—4.6%	6,651	6,401	—3.8%
CEB Difference	862	629	—27.8%	1,784	1,762	—1.2%	3,038	2,876	—5.3%

Source: U.S. Bureau of the Census, *Census of Population*, Vol. 1, Part 20, *Louisiana*, Table 51 (1960); Table 52 (1970).

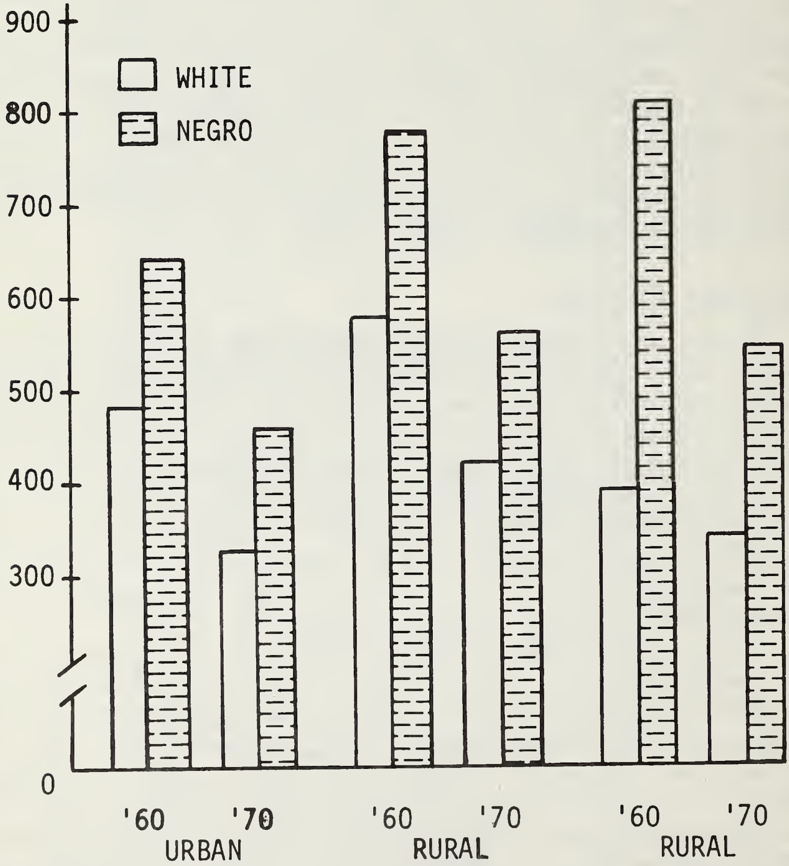
Finally, let us compare the changes in fertility for each age, sex, and residence group. One can see in Table 3 that no clear pattern of change occurred. The greatest decrease in CEB occurred among the youngest age group (15 to 24). Urban young women of both races had one-fourth fewer children in 1970 than their 1960 counterparts. Urban and rural nonfarm whites had greater decreases than Negroes, but rural farm Negroes had a greater decrease than rural farm whites in this age group. For women in the 25 to 34 year age group, the decrease in CEB rates was much lower. Negro rural nonfarm women had the greatest decrease (−7.2%), followed by white rural farm women (−6.5%). Urban women of both races had the lowest decrease for this age group.

Changes among the oldest age group (35 to 44) are a little surprising. Rural farm women registered small decreases, rural nonfarm women slight increases, and urban women the greatest increase. Negro women had larger increases *and decreases* than their white counterparts in each residence category. Note that for all age groups and races in Table 3, rural farm fertility has declined. The patterns for urban and rural nonfarm women are similar; however, rural nonfarm women in the 35 to 44 age group experienced a much more moderate increase in CEB than did their urban counterparts.

Current Fertility

By looking at the CEB rates for the youngest ages (15 to 24) we can get an idea about the current fertility of this group, but the picture becomes blurred for older women because the CEB includes all births up to a certain time point (i.e., the Census year). As we noted earlier, the child-woman ratio provides a good approximation of current fertility since it uses only children less than five years old. Unfortunately this ratio cannot be computed for discrete age groups. However, a comparison of the child-woman ratios for urban, rural nonfarm, and rural farm women in 1960 and 1970 by race, in Figure 8, is suggestive of the recent fertility behavior of these populations.

Unlike the CEB rates in Figure 7, there is a consistent and, with one exception, considerable decrease in child-woman ratios from 1960 to 1970. The greatest decrease (−31.3%) was registered by rural farm Negroes and the least decrease (−12.3%) by rural farm whites. The consequence of these two decreases has been to reduce the difference between white and Negro child-woman ratios among the rural farm population by a sizable 49.6%. The child-woman ratio of Negroes was 103.0% greater than for whites in this population in 1960 but only 59.2% greater in 1970. In the rural nonfarm population, decreases for whites and Negroes were almost identical (−26.7% versus −27.7%). So the ratio of Negro to white fertility remained constant. Negro fertility was 34.8% greater in 1960 and 32.9% greater in 1970. However, the absolute size of the difference declined from 202 per 1,000 to 140 per 1,000, or a minus 30.7%. While child-woman ratios declined for both urban whites (–30.1%) and Negroes (–20.3%), the difference between the two groups actually increased from 33.2% in 1960 to 36.5% in 1970. The absolute size of the ratio did decrease somewhat from 160 per 1,000 to 123 per 1,000, or a minus 23.1%. From the child-woman ratio we can conclude that substantial decreases were experienced by all women regardless of race or residence. Also, there was generally a reduction of white-Negro differences in fertility. Despite these decreases, the fertility of the Negro population remains substantially higher than that of whites.



Source: U.S. Bureau of the Census, Census of Population, Vol.1, Part 20, Louisiana, Table 37(1960), Table 48(1970)

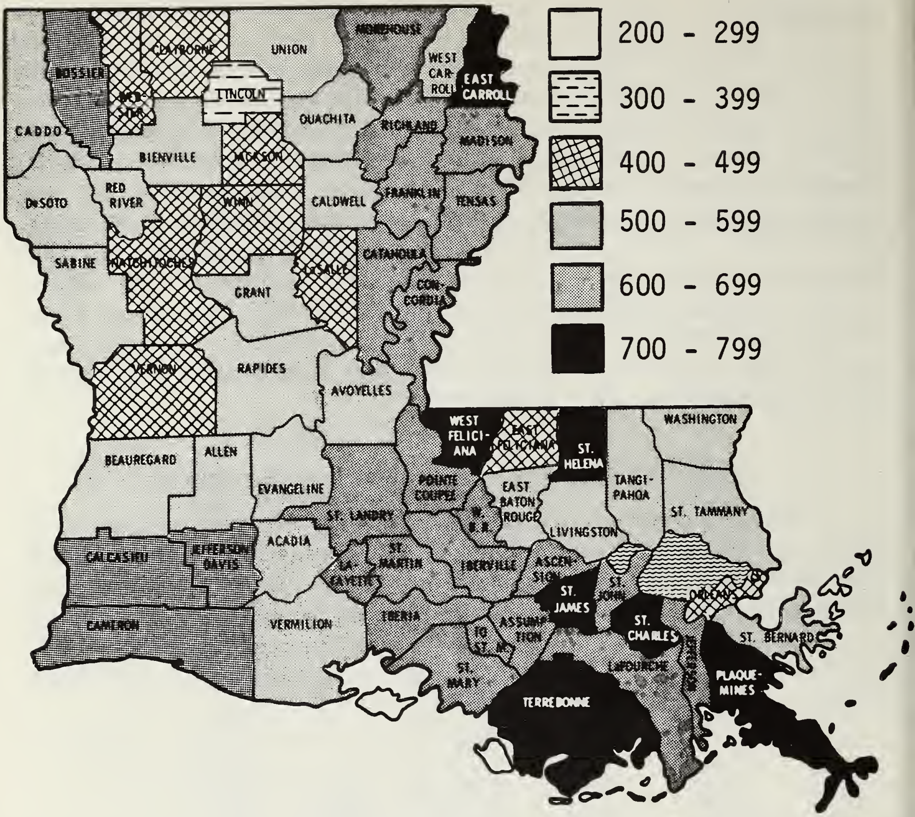
Figure 8.–Child-Woman Ratios by Race and Residence, 1960 and 1970.

Summary

It is obvious that fertility among Louisiana women declined from 1960 to 1970. The decline is most apparent in the youngest age groups. Both whites and Negroes have experienced the decline. The fertility gap between whites and Negroes is also closing slightly, particularly at the younger ages and in the rural areas. However, there remains a considerable difference between the races. Education, occupation, labor force participation, and income all affect fertility and the Negro-white differences in fertility. Improvement of the status of Negroes with respect to these variables produces not only lower fertility but also a trend toward convergence of Negro and white fertility levels. In the next section we will further explore the impact that such fertility differentials have upon fertility at the parish level.

Fertility Differentials Among Parishes

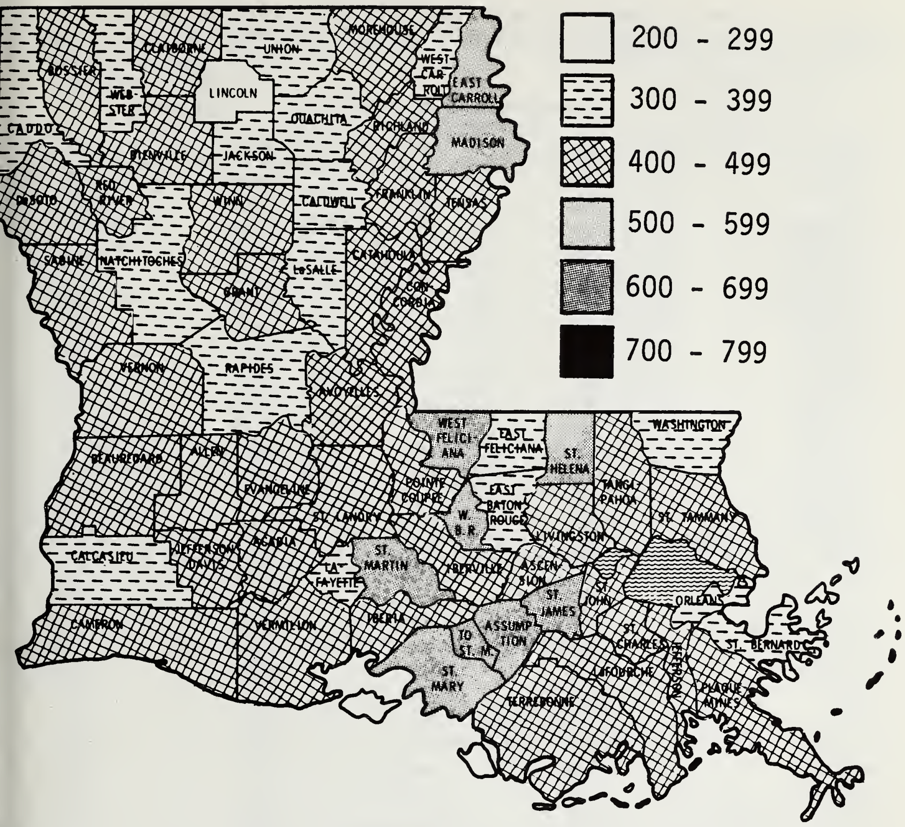
Having considered changes in fertility for the total population of Louisiana, let us now turn to looking at fertility at the level of the individual parish. We have examined the importance of various fertility differentials in explaining variations in the level of fertility among Louisiana's 64 parishes. Considerable changes occurred in fertility within parishes from 1960 to 1970. One can see parish fertility for these two periods in Figures 9 and 10.



Source: U.S.Bureau of the Census. Census of Poupulation,
Vol. 1, Part 20, Louisiana, 1960, Table 13.

Figure 9.–Children under Five Years of Age per 1,000 Women 15-49 Years of Age by Parish for 1960.

One can see from the maps that no parish in 1970 remained at the high levels recorded in 1960. In 1970 the highest child-woman ratios were in East Carroll (583) and Madison (560) parishes. Lincoln (258) had the lowest ratio. While 22 parishes had fertility ratios from 500 to 599 in 1960, only nine parishes had such ratios in 1970. Likewise, though only one parish had a child-woman ratio between 300 and 399 in 1960, 17 parishes had ratios that low in 1970. The fertility measures in Table 4 indicate that the parish with the least change in the child-woman ratio was Vernon (–10.1%). St. Bernard Parish had the greatest change (–39.3%) in child-woman ratio. High fertility in 1960 was heavily concentrated in the parishes along the Mississippi River. Low fertility



Source: U.S.Bureau of the Census. Census of Population,
Vol. 1, Part 20, Louisiana, 1970, Table 16.

Figure 10.—Children under Five Years of Age per 1,000 Women 15-49 Years of Age by Parish for 1970.

was most characteristic of the Northern nonriver parishes and Orleans Parish. In 1970 low fertility continued to be found most in the Northern parishes, but was also found in several of the metropolitan southern parishes. On the whole, parish fertility was much more uniform in 1970. Approximately 60% of the parishes had child-woman ratios of 400 to 499.

We have previously shown that fertility varies according to other characteristics of the population. Such characteristics are called fertility differentials. Ten social, economic, and demographic characteristics which previous research has shown to be related to fertility were

Table 4.—Fertility of the Parishes in Louisiana, 1960 and 1970

	Child-Woman Ratio		Children Ever Born per 1,000 Ever Married Women 35-44 Years Old	
Parish	1960	1970	1960	1970
Acadia	590	458	3,509	3,527
Allen	590	454	3,836	3,914
Ascension	675	497	3,746	3,683
Assumption	659	541	4,062	4,282
Avoyelles	567	455	3,989	3,677
Beauregard	521	416	3,322	3,532
Bienville	501	446	3,878	3,765
Bossier	630	401	2,889	3,128
Caddo	518	365	2,705	3,030
Calcasieu	615	384	3,034	3,417
Caldwell	557	391	4,137	3,710
Cameron	629	460	3,000	3,875
Catahoula	640	406	3,622	3,980
Claiborne	488	430	3,755	3,152
Concordia	638	441	3,807	3,678
DeSoto	562	426	4,062	3,847
East Baton Rouge	518	347	2,751	3,166
East Carroll	713	583	4,663	4,364
East Feliciana	473	396	3,322	3,246
Evangeline	567	479	3,710	4,058
Franklin	626	461	4,436	3,950
Grant	507	402	3,816	3,057
Iberia	641	477	3,423	3,962
Iberville	660	477	3,949	4,083
Jackson	464	382	3,134	3,339
Jefferson	612	402	2,722	3,065
Jefferson Davis	625	442	3,635	3,773
Lafayette	603	392	3,084	3,441
Lafourche	632	486	3,544	3,779
LaSalle	484	388	2,975	3,552
Lincoln	383	258	2,912	2,945
Livingston	585	443	3,627	3,487
Madison	690	560	4,310	4,419
Morehouse	622	454	3,579	3,794
Natchitoches	497	338	3,857	3,547
Orleans	476	349	2,580	3,096
Ouachita	547	386	3,012	3,121
Plaquemines	702	476	3,664	3,580
Pointe Coupee	661	473	4,500	4,334
Rapides	544	383	3,157	3,359
Red River	576	427	3,832	4,038
Richland	612	429	4,451	3,759
Sabine	527	459	4,047	3,922
St. Bernard	596	362	2,763	3,040
St. Charles	754	472	3,728	3,691
St. Helena	709	514	4,749	4,585
St. James	736	514	5,113	4,430
St. John the Baptist	693	498	3,973	4,255
St. Landry	630	452	4,422	4,075

(continued)

Table 4.—(continued)

Parish	Child-Woman Ratio		Children Ever Born per 1,000 Ever Married Women 35-44 Years Old	
	1960	1970	1960	1970
St. Martin	672	500	4,433	4,191
St. Mary	680	511	3,607	3,759
St. Tammany	598	407	3,553	3,417
Tangipahoa	576	414	3,594	3,435
Tensas	694	473	4,667	4,178
Terrebonne	704	495	3,900	3,815
Union	525	390	3,661	3,849
Vermilion	572	441	3,236	3,668
Vernon	484	435	3,360	3,135
Washington	580	386	3,545	3,542
Webster	473	352	3,021	3,153
West Baton Rouge	687	501	3,737	3,713
West Carroll	526	398	4,670	3,862
West Feliciana	706	515	4,411	4,156
Winn	497	416	3,564	3,863

Source: U.S. Bureau of the Census, *Census of Population,* Vol. 1, Part 20, *Louisiana,* Tables 13, 82 (1960); Tables 16, 43 (1970).

selected.[5] These differentials included the following parish characteristics:[6]

1. Educational Attainment of Males
2. Educational Attainment of Females
3. Female Earnings
4. Family Income
5. Female Employment
6. Employment in Agriculture
7. Urban Population
8. Nonwhite Population
9. Females 20 to 34 Years Old
10. Marital Status of Females

The zero-order correlations indicated that, for both 1960 and 1970, low fertility was significantly associated with high educational attainment for males and females, a higher percentage of the female population in the labor force, and high earnings for employed females.[7] In 1960 and

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[5] See J. Allan Beegle, "Social Structure and Changing Fertility of the Farm Population," *Rural Sociology,* Vol. 31, 4, Dec., 1966, pp. 415-427. Lee Jay Cho, et al., *Differential Current Fertility in the United States.* (Chicago: The University of Chicago Press, 1970). Deborah Freedman, "The Relation of Economic Status to Fertility," *American Economic Review,* Vol. 15, 2, Nov., 1961, pp. 161-173. Wilson Grabill, et al.. *The Fertility of American Women.* (New York: John Wiley and Sons, Inc., 1958). Rodger Rice and J. Allan Beegle, *Differential Fertility in a Metropolitan Society.* (Morgantown: West Virginia University, 1972).

[6] For explicit definitions of these variables see Figure A-1 of the Appendix.

[7] The zero-order correlations are presented in Table A-1 of the Appendix.

1970, fertility increased as the proportion of nonwhites in the population increased and as the proportion of the work force employed in agriculture increased. Only in 1960 was there a significant relationship between the percentage of females aged 20 to 34 and parish fertility. In that year, more women in this age group were associated with higher fertility. Only in 1970 did we find a significant relationship between fertility and the proportion of the population living in urban places as well as the median family income of the parish. Fertility decreased in 1970 as the urban population and family income increased. The zero-order correlations failed to support any relationship between the percentage of females married and parish fertility in both 1960 and 1970.

Next we wanted to see which of our ten variables had the greatest effect upon parish fertility in 1960 and 1970. The relative importance of each variable can be assessed by using the statistical technique of multiple regression analysis discussed earlier in this report. This technique found that only seven of the original ten variables were helpful in explaining parish fertility. These seven variables were "educational attainment of the males," "median family income," "percent females in the labor force," "percent nonwhite," "percent females 20-34 years old," "percent employed in agriculture," and "percent females married." The variables were observed to have influenced fertility to the same extent in both 1960 and 1970, except for "median family income."[8] The impact of family income on fertility has weakened significantly (in a statistical sense) over the 10-year period. The seven characteristics in combination explained approximately three-quarters of the total variation in fertility among the parishes in 1960 and 1970 (78% in 1960 and 76% in 1970). The other one-quarter of variance could most probably be accounted for by those characteristics we were unable to include in this study, such as religious affiliation, ethnic background, age of marriage, and so on. "Percent nonwhite" was the characteristic found to have the highest explanatory power for both census years. It alone has explained 10.2% of the fertility variance among parishes in 1960 and 23.6% of the variance in 1970.

Regarding male education, our regression coefficients indicated that for every unit (school year completed) increase in male educational attainment there was a proportional decrease in the fertility ratio of the parish for both 1960 and 1970. However, such a relationship was not found for female education and fertility. When the effects of all other socio-economic factors were eliminated, that is, when parishes with similar median male education, median family income, percentage of females employed, and similar other characteristics were compared with one another, female education was no longer influential in explaining fertility variation. In other words, female education by itself was not significantly related to fertility.

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[8] The regression coefficients and partial correlation coefficients are presented in Table A-2 of the Appendix.

In the case of median family income, its relationship with fertility reversed totally when the effects of all other nine variables were removed. The result of the multiple regression analyses indicated that high median family income by itself was associated with high fertility. This relationship is opposite to the result of the simple correlation. Such an outcome was analogous to the findings of a previous study by Freedman in which couples within a specific social class who could afford the same life style as their peers and still had extra money left tended to have relatively more children; whereas when fertility was compared across the social classes, the upper class tended to have fewer children than the lower class.[9]

The percentage of females employed in a parish was related to fertility in the same manner in the multiple regression analyses as in the simple correlation. Female earnings, on the other hand, lost its influence on fertility variation after all other factors were controlled.

The result of the multiple regression analyses reinforced previous findings that high fertility was consistently related to a high percentage of the population engaged in agricultural occupations. The persistence of such a relationship might be due to the probability that children still have a high economic value in the agricultural production enterprise and that the large proportion of in-family activities on a farm favors a greater number of children.

No meaningful relationship was found between fertility and "percent urban," *per se*. The lack of a significant relationship is in contradiction to the earlier findings reported in this bulletin. You may remember that urban residents always had lower fertility than rural residents. Our results suggest that these differences are a product of the characteristics of the urban and rural populations. When we control for the other variables (education, income, etc.), whether or not a person lives in a rural or urban area is not important. Rural fertility is higher than urban fertility because rural areas have more of the type of people that have higher fertility than they do of persons who have low fertility.

The percentage of nonwhite in the parishes was found to have an independent effect on fertility. It has been found in a study by Beegle that when rural nonwhites were compared with rural whites of the same social status in the South, nonwhites still had a higher fertility.[10] This phenomenon has been explained as a result of the dualistic structure in the South in which the nonwhites (mostly Negro) have not been fully assimilated into the dominant white culture. In this specific case, rural nonwhites in the South have not accepted two to four children as their ideal family size, as have the whites. Our analysis for both 1960 and 1970 also indicates that both the proportion of the female population between the ages of 20 and 34 years and the percentage of females who are married are positively associated with high levels of fertility.

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[9] *Op. Cit.*, pp. 161-173.
[10] *Op. Cit.*, pp. 415-442.

Conclusions and Implications

The most important characteristics of the population affecting the fertility levels of parishes were male education, family income, females in the labor force, race, females 20 to 34, marital status of the females, and employment in agriculture. The results of our statistical analysis support the descriptive materials presented in the first section of this report. Also, these results clarify some of the associations made in the first section. High rural fertility appears in rural areas mainly because most of these areas have large populations who are employed in agriculture and who are Negro. Employment in agriculture is also strongly associated with low income and education, as is being a Negro.[11] Taking all the significant differentials together, one can predict the level of fertility in any parish according to the distribution of these variables within the population. These variables represent the underlying determinants of parish fertility and most probably of fertility in the state as a whole. We suggest that future levels of fertility will in part be determined by the distribution of these fertility differentials within the total population.

For example, the ratio of whites to Negroes should have an impact, as well as the geographical distribution of the two groups. Movement from a rural to an urban environment implies movement out of agriculture, as well as eventual improvement in income and improved educational opportunities for children. However, such an improvement in socio-economic status also could be achieved without rural to urban migration by means of economic and social development of rural areas.

Let's look at what was happening in Louisiana between 1960 and 1970 with respect to these two factors. The proportion of whites in the Louisiana population increased by 2.2% over the decade, with a comparable decrease in Negroes. The decrease in the Negro population was a consequence of their high rate of out-migration (−14.9%) for the decade compared with a moderate rate of in-migration (+1.3%) for whites. Thus the total Negro population increased only 4.6%, while the total white population increased by 14.9%. The effects of migration can also be observed by looking at the rates for females 15 to 29 years of age. Whites had an in-migration rate of +1.4%, while Negroes had an out-migration of −36.0% (−40,612 women).

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[11] According to the 1970 Census of Population the median family income of an urban Louisiana family was $8,200 in 1969 compared with $6,377 and $5,560 for the rural nonfarm and farm populations, respectively. Among the rural populations over one-fourth (28%) had incomes below the poverty level. Eighteen percent of the urban population was "in poverty."

Whites increased in proportion to Negroes in all residence categories (Urban, Rural Nonfarm, Rural Farm, Metropolitan, and Nonmetropolitan). However, the greatest increase was in the rural farm areas (+12.7%). The number of whites and Negroes living in urban places increased 17.3% and 14.8%, respectively. But while the number of whites living in rural areas increased by 10.6%, the number of Negroes there decreased by 12.0%. Both whites and Negroes increased their numbers in metropolitan areas, but Negroes were locating in the central cities (+14.4%) and whites in the suburbs (+39.2%). Negroes decreased their numbers in nonmetropolitan parishes by 2.3%, but whites increased by 14.9%. The tendency of the Negro population to increase at a slower rate than the white population, along with its urbanization, should contribute to a continued decline in Louisiana fertility.

Another important change contributing to the decline in fertility has been the decrease in employment in agriculture. The percentage of Negro males employed in agriculture in 1970 declined by one-half, from 18.8% in 1960 to 9.7% in 1970. Among white males there was a decrease from 7.0% in 1960 to 4.8% in 1970. Also, both races experienced an increase in median family income, with Negro median family income rising 78.9% versus 66.8% for white income. However, the dollar difference in income between Negroes and whites actually increased from $3,050 in 1960 to $4,816 in 1970. While both races are taking on more of the attributes of low fertility populations, it is unlikely that the gap between the two will disappear, because of the disparity in the socio-economic conditions between them.

We have shown that an important factor in the changing fertility of the state from 1960 to 1970 has been the changing socio-economic and demographic characteristics of the population. However, such characteristics are not the only factors affecting fertility. Attitudes toward childbearing and toward desired number of children are also important. Nationally, the trend has been for women to reduce their childbearing expectations. The proportion of women wanting more than four children declined from 40% in 1967 to 23% in 1971.[12] Such attitudes are consistent with the actual performance of Louisiana women. From 1965 to 1972, there was a decline in the number of women giving birth to three or more children. At the same time the number of births that were either a first or second child were increasing.[13] It appears that this trend to stop with two children is here to stay. Thus, the year to year fluctuations in fertility will be most strongly affected by the intervals parents choose for having children (i.e., the childspacing behavior of the parents.)

Implications derived from the study may be summarized as follows:

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[12] Gallup Opinion Index, Report No. 69, March, 1971: 19.

[13] 1972 Statistical Report of the Bureau of Vital Statistics, Louisiana State Department of Health.

Fertility directly affects the growth of the population and its age structure. High fertility means an increased population as well as a younger one, while low fertility reduces population growth and the proportion of children. Migration may either accelerate or restrain fertility effects. Its impact depends upon characteristics of the migrant population such as age, race, education, and occupation, as well as whether the migrants are leaving or entering the population.

Social issues related to fertility may be put into two contexts. First, there are the personal implications of large family size. Basically, this question revolves around the positive or negative effects of having many children. It also includes the issue of unwanted pregnancies. Then there are the social implications of fertility. Numerous public and private agencies are affected by fertility due to its impact upon the composition of the population and its uneven distribution among various segments of that population. These agencies are involved in fertility from two main perspectives. One approach emphasizes control of fertility, while the other takes a more reactive perspective. The latter approach is best typified by the public schools which must adjust to changes in the size of the school-age population. They must also deal with the composition of that population with respect to socio-economic background. Family planning programs typify the former approach. They seek to influence fertility levels among the populations and to control certain types of fertility such as illegitimate and unwanted births.

Agencies interested in controlling fertility should direct their efforts toward the rural areas, especially those with a large agricultural work force and a large Negro population. Control of fertility in rural areas would not only relieve this area of some of the burdens of servicing a young and poor population but would also help to reduce rural to urban migration and discourage overurbanization. This reduction would also relieve cities of some of the burden of growth that they have been experiencing.

While agencies that must adapt to population change can look for some relief from the decline in fertility, substantial differences among different population groups will still require adjustments. Clearly, it is in the rural areas that the greatest burdens of fertility are felt. Logically, these areas have the greatest need for assistance. It is also apparent that families of some segments of the population have considerably greater needs than others due to their higher fertility. Unfortunately, these are the families with the fewest resources for meeting those needs.

Two strategies for dealing with this problem would be to improve the overall status of these groups and to provide supplementary services. These groups, especially Negroes, need to be brought into the educational and economic mainstream. Furthermore, for children raised in disadvantaged family situations to have a chance, there must be programs available to overcome the effects of limited family resources. The recent emphasis on trade schools by the state is an example of one possible strategy. Trade schools are especially needed in rural areas so that young people can move out of the agricultural sector. Also, the location of trade schools in rural areas would provide a resource base for their economic development.

Given the picture of fertility we have painted, the reader can probably think of additional solutions or alternatives, as well as implications. As the age composition of the population changes, the Louisiana citizen is faced with the task of reassessing public policies. Will fewer children mean that more money will be spent per child and the quality of the services improved, or will total resources be reduced? What about services for the growing aged population? How much should be invested in fertility control programs and what should be their direction? These issues, as well as others, remain to be resolved. We have tried to present information that will give the reader an informed perspective for confronting the changing pattern of fertility occurring in Louisiana.

Summary

1. A decline in fertility from 1960 to 1970 was experienced by all of the racial groups in the Louisiana population. While some closing of the gap between Negro and white fertility was discovered, Negro fertility continues to be higher than white fertility. Exceptions occur in the highest socio-economic strata, where white fertility actually exceeds Negro fertility.

2. Over the 10-year period, the greatest reduction in fertility has occurred within the younger age groups (i.e., those under 25 years of age).

3. Rural women continued to have higher fertility than their urban counterparts. Also, women in nonmetropolitan areas had higher fertility than those in metropolitan areas.

4. Negro fertility declined at a higher rate than did white fertility, especially in rural areas.

5. Fertility has generally been decreasing in the state, with rates in the separate parishes becoming less differentiated since 1960.

6. Seven population characteristics are significantly related to differences in parish fertility levels. These include male educational attainment, family income, female employment, employment in agriculture, percentage of nonwhite in population, percentage of females 20 to 34 years old, and the percentage of females married. The single most important predictor of parish fertility is the percentage of the population nonwhite. As this percentage increases, fertility increases.

Appendix

Figure A-1. Operationalization of Independent Variables.

1) *Educational Attainment of the Males*: is measured by the median number of school years completed by the total number of males 25 years old and over.

2) *Educational Attainment of the Females*: is measured by the median number of school years completed by the total number of females 25 years old and over.

3) *Family Income*: is the median total incomes of all members 14 years old and over in each family.

4) *Percent Females in the Labor Force*: consists of the females 16 years old and over in the civilian labor force for 1970, and females 14 years old and over for 1960.

5) *Female Personal Earnings*: is measured by the median earnings of females 16 years old and over (1970), or 14 years old and over (1960) in the experienced civilian labor force.

6) *Percent Agriculture*: is measured by the proportion of employed persons of both sexes 16 years old and over (1970) or 14 years old and over (1960) in agriculture, forestry, and fisheries.

7) *Percent Urban*: for each county, designates the percentage of the population residing in urbanized areas, and in places of 2,500 inhabitants or more outside urbanized areas.

8) *Percent Nonwhite*: is defined as the proportion of persons of such races as Negro, Indian, Japanese, Chinese, Filipino, Korean, Asian Indian, and Malayan races.

9) *Percent Females 20-34 years old*: is the number of females 20-34 years old per 100 females within the childbearing range of 15-49 years old.

10) *Percent Females Married*: is the percentage of females 14 years old and over who are married once or remarried at the time of the census enumeration.

Figure A-2. The Multiple Regression Model.

Multiple Regression Model. The multiple regression model we propose for each census year is as follows:

$$Y_i = \alpha + B_1X_{i1} + B_2X_{i2} + \ldots + B_jX_{ij} + B_{10}X_{i10} + e_i$$

where i = 1st, 2nd, 3rd, . . . 64th parish

j = 1st, 2nd, 3rd, . . . 10th independent variable

and Y_i = child-woman ratio of the ith parish

X_1 = male education

X_2 = female education

X_3 = family income

X_4 = female employment

X_5 = female earnings

X_6 = percent agriculture

X_7 = percent urban

X_8 = percent nonwhite

X_9 = percent females 20-34 years old

X_{10} = percent females married

e is the ith random disturbance term

B_j is the partial regression coefficient of the jth independent variable. It shows the change in Y per unit change in the accompanying independent variable X holding constant all other variables;

α is the true value of Y when each of the independent variables has a value of zero.

TABLE A-1.—Zero-Order Correlation Coefficients Between Fertility and its Determinants in 64 Louisiana Parishes in 1960 and 1970

Independent Variable	Zero-Order Correlation Coefficients	
	1960	1970
X_1 Male education	–0.34**	–0.55**
X_2 Female education	–0.46**	–0.60**
X_3 Family income	0.06	–0.24*
X_4 % Female employed	–0.27*	–0.58**
X_5 Female earnings	–0.26*	–0.54**
X_6 % Agriculture	0.34**	0.48**
X_7 % Urban	–0.10	–0.32**
X_8 % Nonwhite	0.24*	0.31**
X_9 % Female, 20-34 years old	0.41**	–0.06
X_{10} % Female married	0.11	0.06

*Statistically significant at the 5% level.
**Statistically significant at the 1% level.

TABLE A-2.—Regression Analysis of Fertility Differences in Louisiana, Their Regression Coefficients, and Partial Correlation Coefficients, 1960 and 1970

Independent Variable	Regression Coefficient		Partial Correlation Coefficient	
	1960	1970	1960	1970
X_1 Male education	–21.65	–14.23	–0.24	–0.18
X_3 Family income	0.04	0.01	0.17	0.16
X_4 % Female employed	–3.24	–3.15	–0.14	–0.17
X_6 % Agriculture	3.49	3.52	0.27	0.26
X_8 % Nonwhite	3.11	3.53	0.32	0.49
X_9 % Female, 20-34 years old	9.83	5.87	0.27	0.23
X_{10} % Female married	5.68	8.12	0.17	0.36
X_2 Female education				
X_5 Female earnings				
X_7 % Urban				
R^2 1960	0.776			
1970	0.758			

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SOME LEGAL ASPECTS OF CATFISH AND CRAWFISH FARMING IN LOUISIANA: A CASE STUDY

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AGRICULTURAL EXPERIMENT STATION
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Some Legal Aspects of Catfish and Crawfish Farming in Louisiana

A Case Study

Elizabeth Williams[1], Frank S. Craig, III[1] and
James W. Avault, Jr.[2]

Abstract

Laws pertaining to aquaculture are lacking. Many laws, pertaining to wild stocks of aquatic species, conflict with normal aquaculture operations. This publication is a case study, or an inventory, of laws pertaining to catfish and crawfish farming in Louisiana.

Introduction

Catfish and crawfish farming have become integral parts of Louisiana agriculture. In 1975, approximately 6,500 acres of ponds were devoted to catfish farming in Louisiana, and over 44,600 acres of ponds to crawfish farming.

The laws pertaining to fish farming in Louisiana are confusing because some laws existing before fish farming became an important industry conflict with laws enacted more recently. As fish farming becomes more intensive, legal questions will have to be resolved in the courts, and more comprehensive legislation will be needed.

This publication provides a brief survey of laws pertaining to catfish and crawfish farming in Louisiana. It calls attention to some legal issues and uncertainties, and also suggests precautions to be observed by present and prospective fish farmers.

What Is Fish Farming? Who Is a Fish Farmer?

In recognition of the increasing impact of fish farming on the state's economy, the Louisiana Legislature passed a series of laws governing

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[1] Louisiana State University Law Center.

[2] School of Forestry and Wildlife Management.

This research was supported by the Louisiana Agricultural Experiment Station and by a grant from the Louisiana State University Sea Grant program through National Oceanic and Atmospheric Administration, Department of Commerce.

domestic aquaculture and fish farming in the 1960's and 1970's.[3] These laws define certain key terms such as "fish," "agriculture," "domesticated fish," "privately owned waters," and "farming" in ways important to the fish farmer.

Louisiana law defines "fish" as "all fish, shellfish, crustaceans, frogs, turtles, and other aquatic organisms which have a sport or other economic value."[4] This broad definition thus includes not only fin fish but also crabs, crawfish, shrimp, and any other water animal which could be raised commercially.

"Agriculture" or "agricultural pursuit" or like terms are defined as including "the cultivation, growing, harvesting and/or marketing of domesticated fish."[5] The statutes further state that crops cultivated on fish farms include "domesticated fish which are grown, managed or harvested on an annual, semiannual, biennial or short-interval basis."[6] "Livestock" includes "domesticated fish which are grown, managed, harvested and/or marketed as a cultivated crop."[7] "Domesticated fish" refers to any fish that are "spawned and grown, managed, harvested and marketed on an annual, semiannual, biennial or short-term basis, in privately owned waters, when properly approved and regulated by the Louisiana Wildlife and Fisheries Commission."[8] "Privately owned waters" refers to waters contained in "artificial earthern reservoirs" which must be "constructed with levees so as to prevent at all times the ingress and egress of fish life from public waters."[9] Thus fish grown for market in a privately owned pond are considered "domesticated" and are an agricultural product.

While Louisiana law does not specifically define "fish farmer," according to a federal definition, the term "farming" includes a person who engages in fish farming.[10] This is important on the federal level because it makes fish farmers eligible for agricultural benefits such as certain agricultural operational loans.[11]

Fish farmers should also be qualified for disaster benefits during floods, hurricanes, and the like. Crawfish farmers in St. Martin Parish have already been examples of fish farmers receiving benefits. However, a catfish farmer in Franklin Parish was unable to obtain such benefits. This matter should be clarified (James Fowler, personal communication, 1975).

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[3] Act 245 of 1964, Act 242 of 1966, Act 77 of 1970, Act 453 of 1970, and Act 627 of 1970. See also Act 223 of 1974 which revised most of the Louisiana laws dealing with fisheries.

[4] La. R.S. 56:311(18).

[5] La. R.S. 56:311(1) & 56:411(1).

[6] La. R.S. 56:411(2).

[7] La. R.S. 56:411(3).

[8] La. R.S. 56:311(15). See also La. R.S. 56:411(4).

[9] La. R.S. 56:411(5).

[10] 7 U.S.C. 1991.

[11] For information as to what is available see local Soil Conservation Service agents, Agricultural Extension agents or contact the Farmers Home Administration.

Permit To Begin Fish Farming

To raise domesticated fish for commercial markets, a farmer must first apply to the Louisiana Wildlife and Fisheries Commission for a Fish Farmer's License and pay a $10 fee. The license expires annually on December 31 and another $10 fee is charged for renewal.[12] The license can be obtained by writing to Louisiana Wildlife and Fisheries Commission, P. O. Box 44095, Capitol Station, Baton Rouge, La. 70804.

Pond Location and Construction

In deciding where to locate a catfish or crawfish pond, a farmer should consider several state laws which restrict his choice. Man-made ponds "within the basin of a continuously flowing river, bayou or other stream"[13] or those which use "lands of natural streams or natural lake beds"[14] are subject to all laws and regulations which apply to the taking of fish in public waters. Such artificial ponds fall outside of the definition of "privately owned waters," and fish raised in such ponds are not "domesticated fish."[15] A farmer with a man-made pond in a river basin would be limited as to kind, number, and size of fish he could harvest, and certain harvesting techniques would be prohibited. In other words, a pond built in a river basin would be useless, by law, for fish farming purposes, as the farmer would be subject to all laws regulating regular commercial fishermen.

Fin fish farmers are also prohibited from using public bodies of water to raise fish. Thus the use of cages, pens, or fenced off portions of public waters to raise fin fish is illegal.[16]

There are no specific state laws regulating the construction of ponds or reservoirs on private property. There are general provisions in Louisiana law, however, prohibiting the use of one's private property in a manner which damages the property of another. Thus one who constructs a pond on his property is responsible for any damage caused to neighboring property owners.

Moreover, local parish and municipal zoning ordinances may regulate pond construction on private property in some locations, or municipal zoning may prohibit building of commercial, industrial, or agricultural structures within city limits. Also, parish or municipal construction codes may require that ponds be constructed to meet certain specified standards. Any person wishing to construct fish ponds on his property should check with parish and municipal offices to learn about building restrictions and permit requirements.

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[12] La. R.S. 56:412(1) & (2).

[13] La. R.S. 56:27(c).

[14] La. R.S. 56:411(5).

[15] See La. R.S. 56:411(4) & (5) & La. R.S. 56:27.

[16] La. R.S. 56:412(5).

For information and aid in designing and constructing ponds, fish farmers should contact their local Soil Conservation Service agent.

Water Source

Water, of course, is a primary consideration to the fish farmer. In Louisiana there are two major sources of water: (1) a state-owned stream; (2) a private well.

The 1974 regular session of the Legislature eliminated the requirement that persons taking water from state-owned streams use approved screens to prevent the destruction of fish;[17] nevertheless, it is advisable that water from streams be screened to prevent introducing trash fish into the pond.

If well water is used, one must be aware of three recent laws regulating wells which produce in excess of 50,000 gallons in any one day of a given year. One, passed in 1972, requires that all such wells be registered with the Department of Public Works.[18] The second, passed in 1975, implements procedures for registering wells capable of producing more than 50,000 gallons per day.[19] The other act, passed in 1974, establishes not only a registration requirement but also a permit system applicable at this time to East and West Baton Rouge, East and West Feliciana and Pointe Coupee Parishes. The Capitol Area Groundwater Conservation District will administer this act.[20]

Currently there are no required health checks for the quality of water used in ponds.

Stocking the Pond

A suitable species of fish must be selected by the farmer. In choosing the species to be stocked, there are various restrictions imposed by law. First, the definition of "domesticated fish" specifically excludes "bass, crappie, striped bass, bream, and tetra as well as other exotic fish."[21] These species can only be raised if approval is first obtained from the Wildlife and Fisheries Commission.

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[17] La. R.S. 56:321, 56:361.

[18] La. R.S. 38:3091 et seq.

[19] La. R.S. vol. 1, no. 5, pages 249-253.

[20] Act 678 of 1974. La. R.S. 38:3071-3084.

[21] La. R.S. 56:411(6).

Second, a fish farmer may not sell freshwater game fish.[22] Freshwater game fish are now defined as "any species of fish found in the fresh waters of the state that are taken for sport or recreational purposes."[23] Although this definition is not very specific, a former definition—which listed large- and smallmouth black bass, striped bass, crappie, speckled perch, sac-a-lait, and bream as being types of freshwater game fish[24]—can be looked to for guidance. The state has an interest in protecting its freshwater game supply; thus it does not permit freshwater game fish to be sold whether taken in state waters or from private ponds.[25] However, a person may charge a fee for the privilege of fishing for freshwater game fish in a privately owned pond.

Third, there are laws prohibiting possession, sale, or transportation of certain special varieties of fish. Fish from outside Louisiana can be released in the state only with written consent of the Wildlife and Fisheries Commission.[26] Written consent of the Commission is also required to "possess, sell or cause to be transported into the state" carnero catfish, freshwater electric eels, carp, claiidea, or tilapia.[27] Further, it is illegal to grow or sell for bait or human consumption "obnoxious or undesirable species of fish or minnows";[28] particularly, it is forbidden to possess piranha or Rio Grande tetra.[29]

Growing Fish and Use of Chemicals

Two Federal agencies regulate chemicals used by fish farmers to maintain healthy stock: the Food and Drug Administration (FDA) and the Environmental Protection Agency (EPA).

The FDA regulates those chemicals which may be used on or in food used for human consumption.[30] Thus, the use of certain fungicides or herbicides may be prohibited by the FDA because of the harmful effect to humans caused by residues in the fish.

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[22] La. R.S. 56:327.

[23] La. R.S. 56:311(21) & (23) (1974).

[24] La. R.S. 56:311(6) & (7) (prior to Act 223 of 1974).

[25] La. R.S. 56:27(B) "Statutory and administrative regulations governing or prohibiting the sale or exchange of game fish shall apply to game fish harvested or taken from privately owned man-made ponds or impoundments."

[26] La. R.S. 56:20.

[27] La. R.S. 56:319. There is a conflict between this article, which forbids the possession and sale of "carp," and La. R.S. 56:412(4), which permits the sale of "domesticated carp" (see text on "Marketing" at footnote 43). According to Wildlife and Fisheries sources, apparently the Legislature wanted to prohibit the importation of *non-native* carp yet permit the domestication of *native* carp.

[28] La. R.S. 56:412(3).

[29] La. R.S. 56:319(E).

[30] 21 CFR 3.

The EPA has published regulations on the use of insecticides, fungicides, and herbicides which may be harmful to the environment.[31]

The fish farmer must be aware of the regulations of both of these agencies before using chemicals to control diseases, weeds, or parasites in ponds. The detailed regulations of these agencies may be obtained by writing to Food and Drug Administration, Office of Education and Information, Washington, D. C. 20204, and to Environmental Protection Agency, 401 M Street, S.W., Washington, D.C. 20024.

Drainage

The problem of drainage and waste disposal deserves serious consideration by the prospective fish farmer. Although it is permissible to obtain water from public streams, the drainage of polluting substances into natural streams of the state is prohibited.[32] Water pollution control and state water quality standards are under the jurisdiction of the Louisiana Stream Control Commission.[33] The EPA sets the standards at the federal level.

The National Pollutant Discharge Elimination System (NPDES) is that part of the federal law which regulates discharges into navigable waters.[34] Generally a permit showing compliance with NPDES standards is required of those industries that make discharges of any kind into navigable waters. However, due to the efforts of the Catfish Farmers of America and Louisiana Catfish Farmers Association, certain fish farmers have been exempted from the requirements of obtaining a permit to discharge waste water into state-owned streams.[35] For example, fish farms are not required to get permits at this time if discharges of water from either a closed pond or raceway facility occur less frequently than 30 days a year, or if less than 20,000 pounds of fish are produced in a year, even if the discharges occur more than 30 days each year. These farms were excluded because it was determined that they tend to have only minimal adverse impacts on water quality.[36] On March 24, 1975, an opinion by the district court for Washington, D. C., struck down the Environmental Protection Agency regulations excluding most aquaculture activities from the requirement of obtaining a NPDES permit. The court held that, notwithstanding questions of administrative expediency, the Federal Water Pollution Control Act Amendments of 1972 established that all point source discharges are illegal without a permit and EPA did not have the administrative authority to exempt aquaculture activities from the permit requirement. The court, on June 10, 1975, further ordered EPA to propose new regulations, within eight months, bringing aquaculture activities within the NPDES system. Final regulations for these sources must be promulgated within one year. It is not known at this time whether EPA will appeal these decisions.

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[31] 40 CFR 162.

[32] La. R.S. 56:1462-1463.

[33] La. R.S. 56:1431-1446.

[34] The NPDES is the name given to the regulatory system for permits to discharge pollutants from point sources into waters of the United States pursuant to sections 402 and 405 of the Federal Water Pollution Control Act, 33 USC 1251 et seq.

[35] 40 CFR 124 & 125, 38 Fed. Reg. 18000, July 5, 1973.

[36] 40 CFR 124.1, 38 Fed. Reg. 18000, July 5, 1973. The EPA is continuing to study this matter and the regulations may be changed in the future. Some possible guidelines may be found in an April 1974 publication by EPA — "Draft Development Document for Proposed Effluent Limitations Guidelines and New Source Performance Standards for the Fish Hatcheries and Farms Point Source Category."

Fish pond drainage onto another person's property may be arranged by contract agreement with the other landowner. This contract may be limited as to specific provisions and time of duration, or it could be written into the title of the landowner's property, thereby creating a servitude. If the servitude is written into the title, then even if another person buys the land, the right of the farmer to drain on it will still exist. The responsibility for damage to the other person's property caused by the drainage of the pond rests with the farmer.

Harvesting

A fish farmer may harvest as many domesticated fish as he wants, at any time and by any type of seine or tackle,[37] as long as the method harvests the fish alive. Furthermore, fish farmers are allowed to transport all harvesting equipment, except electric fish shocking devices, on public roads and highways,[38] thus exempting them from laws making possession of certain equipment unlawful. Of course, any seines, tackle, or other devices used to harvest fish from fish ponds, if used in public waters, must meet legal requirements regarding harvesting equipment applicable to fishing in public waters.[39]

Processing

The Food and Drug Administration (FDA) and the Louisiana State Health Administration have set standards to ensure that food is fit for human consumption and to require that the processing, manufacturing, and packaging of fish and seafood products are carried out under sanitary conditions and in conformity with good manufacturing practices. These detailed standards were written to cover not only the general requirements for seafood processing but also each element of the various processes used. There are also set standards for plants and grounds, equipment and utensils, sanitary conditions and controls, and the various flavoring methods.[40]

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[37] La. R.S. 56:413.

[38] Id.

[39] La. R.S. 56:413. See also La. R.S. 56:320-323 for the list of illegal methods of taking fish for commercial purposes.

The exact requirements can be obtained by writing to: Food and Drug Administration, Office of Education and Information, Washington, D.C. 20204, and asking for the FDA standards applying to fish or shellfish processing; and to the State of Louisiana Health Administration, Food and Drug Division, P. O. Box 60630, New Orleans, La. 70160, and asking for state regulations on seafood processing plants.

Commercial processors must also comply with standards set by the U.S. Department of Commerce. Certificates of inspection must be applied for and approval can only be obtained after compliance with those standards.[41] Copies of the regulations can be obtained by writing to: U.S. Department of Commerce, Washington, D.C. 20204, and asking for grading and inspection standards for fish and shellfish processing.

The Environmental Protection Agency has regulations on waste discharges from catfish and other seafood processing plants.[42] A manual may be obtained for a nominal fee from the Government Printing Office, Washington, D.C. 20402, by asking for the "Development Document for Effluent Limitation Guidelines and New Source Performance Standards for the Catfish, Crab, Shrimp and Tuna Processing Segment of the Canned and Preserved Seafood Point Source Category."

Municipal and parish ordinances may also apply to fish and crawfish processing. For example, local ordinances applying to slaughtering of livestock may prohibit certain fish processing activities within city limits. It is advisable to check for such provisions with the city or parish attorney in your area.

Marketing

Sale and shipment of harvested crops by fish farmers does not require a special license from the Wildlife and Fisheries Commission. Rather, fish farmers may sell domesticated catfish, carp, drum, and buffalo fish by virtue of their fish farming license provided they notify the Louisiana Wildlife and Fisheries Commission by mail postmarked 48 hours prior to shipment.[43] A duplicate of the notification must accompany each shipment,[44] as must a bill of lading.[45] If fish of any species ordinarily used for human consumption are shipped by other than common carriers to points outside the state, the shipments must be registered with and inspected at designated ports of exit by the Wildlife and Fisheries Commission.[46]

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[40] 21 CFR 128; La. R.S. 40:601-642 (State Food, Drug and Cosmetic Law); General Regulations and Regulations Pertaining to Foods by the Food and Drug Division of the State Board of Health; Chapter VI of the Sanitary Code on Marine and Fresh Water Animal Food Products (Seafoods); and Chapter VII of the Sanitary Code on Eating and Drinking Establishments; Bakeries and Manufacturing Confectioners; Food Manufacturing Plants.

[41] 50 CFR 260, 266, 276, 277, 279.

[42] 40 CFR 408, 39 Fed. Reg. 23134, June 26, 1974.

[43] La. R.S. 56:412(4).

Ownership and Theft

Both the Louisiana Constitution of 1921 and the Louisiana Constitution of 1974 say that the Wildlife and Fisheries Commission is to control and supervise the protection, conservation, and replenishment of the fish and aquatic life of the state.[47] (The new Constitution says *"all* aquatic life.")[48] This constitutional mandate is strengthened by statutes which say that all fish existing in Louisiana are owned by the state[49] and the Wildlife and Fisheries Commission is responsible for their protection.[50] An opinion by the Attorney General in the 1940's stated that the state owns *all* fish, even those in private lakes.[51] If this is still the law, and it seems it is even though there are no court decisions, where does this leave the fish farmer? Does he own the fish in his ponds or not? What happens if someone takes fish without the fish farmer's permission? What if his fish escape after a flood or storm, into a public water body—can he recover them?

The "ownership" question is for the most part not really important because the state has given the fish farmer nearly complete control over domesticated fish. He is protected by laws making it a crime for anyone to take crawfish [52] or domesticated fish from a fish farm or private pond without the owner's consent.[53]

However, the "ownership" issue can be very important to the farmer if the fish in his pond should escape through a break in the pond, flooding, or some other occurrence. While not common events, such incidents have happened. The farmer wants to be able to recapture the fish, but two key problems exist.

First, it is difficult, if not impossible, to tell domesticated fish from wild fish. This could be solved by some sort of tagging or branding system, but no such systems are currently available. It is likely that none will be available because of the vast numbers of fish that would need to be marked.

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[44] Id.

[45] La. RS. 56:412(3).

[46] La. R.S. 56:344.

[47] La. Const. Art. VI §1 (1921).

[48] La. Const. Art. IX §7 (1974).

[49] La. R.S. 56:312.

[50] La. R.S. 56:a, 56:6(14) & (15), 56:313.

[51] Opinions La. Atty. General 1944-1946, p. 85.

[52] La. R.S. 14:226.

[53] La. R.S. 14:67.4.

Second, once the fish escape from the pond, current laws indicate the fish cease to be "domesticated" fish and become subject to all regulations on catching wild fish. Technically, a farmer recatching fish must abide by laws pertaining to types of harvesting equipment, such as nets, hooks, and traps, and the minimum size and maximum number limits as well as the requirements on licenses, registering, etc. applicable to commercial fishermen.

In these situations, the ownership question becomes a very real problem for the fish farmer. It seems that some legislative changes in the law would be needed to properly protect the farmer in the event his fish escape.

Appendix

This appendix has been added as a handy reference guide to the sources of information contained in the publication. The first part provides names and addresses of individuals and organizations able to furnish more specific information about various aspects of fish farming. The second part is a listing, divided similarly to the way the publication is divided, of citations to the laws and regulations mentioned in the publication.

Sources of Information

Louisiana Catfish Farmers Association, Route 1, Box 12, Iowa, La. 70647. Phone: 318-582-6837

Louisiana Catfish Farmers Association, and Louisiana Crawfish Farmers Association, 202G Knapp Hall, Louisiana State University, Baton Rouge, La. 70803. Phone: 504-388-2180

Director, Louisiana Wildlife and Fisheries Commission, 400 Royal Street, New Orleans, La. 70130. Phone: 504-527-5126

Commissioner of Agriculture, Louisiana Department of Agriculture, P. O. Box 44302, Capitol Station, Baton Rouge, La. 70804. Phone: 504-389-5267

Sea Grant Legal Program, 52-60 Law Center, Louisiana State University, Baton Rouge, La. 70803. Phone: 504-388-5931

Food and Drug Administration, Office of Education and Information, Washington, D.C. 20204

National Marine Fisheries Service, U.S. Department of Commerce, Rockville, Md. 20852

Environmental Protection Agency, Office of Information, 401 M Street, SW, Washington, D.C. 20024

Department of Food Science, Louisiana State University, Baton Rouge, La. 70803. Phone: 504-388-2256

State of Louisiana Health Administration, Food and Drug Division, P. O. Box 60630, New Orleans, La. 70160

Statutes

Besides the general information in this publication, you may need the specific statutes which affect fish farming. Louisiana statutes in booklet form may be obtained by writing to the Wildlife and Fisheries Commission. Other sources of laws are the Environmental Protection Agency, the Food and Drug Administration, and the U. S. Department of Commerce. Legislation may also be obtained through the state library or court libraries located in parish seats.

WHAT IS FISH FARMING? WHO IS A FISH FARMER?

Definitions affecting fish farming: (1) Agriculture or agricultural pursuit (2) Cultivated crop (3) Livestock (4) Domesticated fish (5) Privately-owned waters	La. R.S. 56:411(1)
Definition of fish	La. R.S. 56:311(18)
Ownership of fish	La. R.S. 56:312
Control of fisheries by Wildlife and Fisheries Commission	La. Const. Art. VI §1 (1921) La. Const. Art. IX §7 (1974) La. R.S. 56:1, 56:6(14) & (15) La. R.S. 56:313
Definition of "farmer" under federal law	7 U.S.C. 1991
"Agricultural commodity" includes fishery products	7 U.S.C. 1732
Farmers eligible to receive federal operating loans	7 U.S.C. 1941
Purposes of loans, grants for pollution abatement and control projects	7 U.S.C. 1942
Persons eligible for emergency federal loans	7 U.S.C. 1961

POND CONSTRUCTION

See local parish and municipal ordinances.

PERMIT TO BEGIN FISH FARMING

Issuance and renewal of certificates	La. R.S. 56:412(1) & (2)

STOCKING

Releasing game or fish brought from without state; permission needed	La. R.S. 56:20
Exotic fish; importation, sale and possession of certain exotic species prohibited; permit required	La. R.S. 56:319
Taking fish for scientific or educational purpose; permit needed	La. R.S. 56:318

Piranha & Rio Grande Tetra; sale or possession prohibited	La. R.S. 56:319(E)
Protection and conservation of wildlife considerations	16 U.S.C. 668cc. 1-4 50 C.F.R. 17
Regulations of interstate transportation of black bass and other fish	16 U.S.C. 851-854
Shipment for breeding or stock	16 U.S.C. 855

DRAINAGE

Control of waste disposal	La. R.S. 56:1434
Establishment of pollution standards	La. R.S. 56:1439
Illegal discharge of waste	La. R.S. 56:1440
Notice to violators; temporary orders stopping waste disposal	La. R.S. 56:1441
Drainage of noxious, fish-killing substances into streams prohibited	La. R.S. 56:1451
Commissioner of Wildlife and Fisheries to supervise drainage	La. R.S. 56:1452
Penalty for violation	La. R.S. 56:1453
Pollution of waters; recovery of civil damages, attorney general to institute action; jurisdiction in district courts	La. R.S. 56:1446
Definition of water pollution	La. R.S. 56:1461
Pollution of waters; discharge of injurious substances	La. R.S. 56:1462
Penalty for violation	La. R.S. 56:1463
Discharge of untreated wastes into Mississippi River	La. R.S. 56:1464
National Pollutant Discharge System Exception of fish and aquatic animal production facilities	40 C.F.R. 124, 125 33 U.S.C. 1251 et seq.

USE OF CHEMICALS

Regulations for the enforcement of the Federal Insecticide, Fungicide and Rodenticide Act	40 C.F.R. 162 (auth. 7 U.S.C. 135d)
Tolerance and exemptions from tolerances for pesticide chemicals in or on raw agricultural commodities	40 C.F.R. 180 (auth. 21 U.S.C. 346a)

Statements of general policy or interpretation of residue of antibiotics	21 C.F.R. 3 (auth. 21 U.S.C. 371)
Antibiotics used in food-producing animals	21 C.F.R. 3.55
Antibiotics used in veterinary medicine and for nonmedical purposes; required data	21 C.F.R. 3.55
Tolerances for residues of new animal drugs in food	21 C.F.R. 135g (auth. 21 U.S.C. 306b, 371a)

PROCESSING

State of Louisiana Food, Drug and Cosmetic Law	La. R.S. 40:601-642
General Regulations and Regulations Pertaining to Foods by the Food and Drug Division of the State Board of Health	
State of Louisiana Sanitary Code: Chapter VI on Marine and Fresh Water Animal Food Products (Seafoods); and Chapter VII on Eating and Drinking Establishments, Bakeries and Manufacturing Confectioners, Food Manufacturing Plants.	
Inspection and certification processed fishery products, processed products thereof and certain other processed food products (raw and cooked frozen fish)	50 C.F.R. 260 et seq. (auth. 16 U.S.C. 742e; & U.S.C. 1622, 1624)
Food and Drug Administration criteria for sanitary conditions for production of food for human consumption	21 C.F.R. 128 (auth. 21 U.S.C. 342(a)(4) 371(a))
Fish and seafood product requirements	21 C.F.R. 128a (auth. 21 U.S.C. 342 (a)(4) 371(a))

THEFT

Theft of domesticated fish from fish farms	La. R.S. 14:67.4
Theft of crawfish from crawfish farms	La. R.S. 14:226

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Nutrient Removal By an Oat-Ryegrass Mixture And Soil Chemical Changes As Affected by Applied Nitrogen, Phosphorus and Potassium

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R. H. Brupbacher
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Nutrient Removal by an Oat-Ryegrass Mixture and Soil Chemical Changes as Affected by Applied Nitrogen, Phosphorus and Potassium

Marvin Allen, P. E. Schilling,
R. H. Brupbacher and A. T. Harrell[1]

INTRODUCTION AND OBJECTIVES

Agronomists have long been concerned with yield response of crops to applied plant nutrients. The efficiency of utilization of the applied nutrients may be affected by crop yield response, nutrient concentration, losses by volatilization, leaching, and erosion, and changes in soil chemical test values.

The cost of fertilizer in grassland farming dictates that the efficiency with which a forage crop utilizes applied fertilizer be taken into account. Application of high rates of one nutrient may result in excessive uptake of that nutrient, or it may stimulate or suppress the uptake of other nutrients, contributing to an unbalanced condition in the plant. Imbalanced nutrient conditions may be toxic to the plant and may cause toxicity in animals consuming such plants.

Considerable acreage is planted to oat-ryegrass mixtures in southeast Louisiana for cool season pastures. This species combination provides approximately six months of high quality forage when available plant nutrients are in adequate supply. Consequently, grasses that have the capacity for producing high yields of high quality forage will also remove large quantities of plant nutrients from the soil.

An experiment with various rates of nitrogen, phosphorus, and potassium applied annually to an oat-ryegrass mixture was initiated in 1966. Results of the study have been reported in Louisiana Experiment Station Bulletin No. 680. Reported were forage yield, plant concentrations of four minerals, crude protein, cell wall constituent, acid-detergent fiber, and in vitro digestible dry matter.

The objectives of the phase of the investigation reported herein were:

(1) To determine the pounds per acre of N, P_2O_5, K_2O, Ca, and Mg removed in the harvested forage.

(2) To evaluate utilization efficiency of the applied plant nutrients.

(3) To characterize the rate of plant nutrient uptake throughout the growing season.

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(4) To correlate yield, plant nutrient uptake, and soil analyses values.

REVIEW OF LITERATURE

Data by Albrecht *(3)* showed that the addition of lime and phosphorus to the soil resulted in increases of 21% in yield of hay, 30% in crude protein content of the forage, 50% in animal gain per unit weight of forage fed, 17% in efficiency in the use of applied phosphorus, and 80% in efficiency in the use of land as a means of converting part of its native fertility into marketable products.

Garmans et al. *(12)* summarized from available data the approximate pounds per acre of nutrients contained in some forage crops. Coastal bermudagrass, with a yield of 8 tons per acre, removed the following amounts of nutrients: 300 pounds of N, 70 pounds of P_2O_5, 270 pounds of K_2O, 59 pounds of Ca, 24 pounds of Mg, and 35 pounds of sulfur. A 2.5-ton per acre yield of red clover removed 100 pounds of N, 25 pounds of P_2O_5, 100 pounds of K_2O, 69 pounds of Ca, 17 pounds of Mg, and 7 pounds of sulfur.

Allen et al. *(4)* reported on the response of oat-ryegrass forage yield and concentrations of crude protein, P, K, Ca, and Mg to applications of N, P_2O_5, and K_2O. Significant yield increases were noted with applications up to 400 pounds of N per acre and 300 pounds each of P_2O_5 and K_2O per acre. There was about a 1.5 percentage unit increase in crude protein with each 100-pound increase of applied N. The phosphorus concentration in the forage was increased throughout the season with increased rates of P_2O_5. The potassium concentration was higher in the unfertilized forage than in forage that received 100 pounds of K_2O per acre. Applications of K suppressed the Ca and Mg concentrations in the forage. Applications of fertilizer did not appreciably affect the in vitro dry matter digestibility of the forage. Near maximum forage yields were obtained where N-P_2O_5-K_2O were applied in ratios of 2-1-2, 3-2-2, and 4-2-3 with N applications of 200, 300, and 400 pounds per acre, respectively.

Results of greenhouse experiments by Brupbacher and Sedberry *(8)* indicate that, on sandy soils of the Coastal Plains, Ladino clover and Tensas red clover would be expected to respond to applied Mg if the dilute-acid extractable or exchangeable Mg is less than 55 ppm, or if Mg occupies less than 10% of the total cation exchange capacity of the soil.

Woodhouse *(19)*, working with Coastal bermudagrass grown on a Eustis sand with no previous cropping history, reported data indicating that approximately 0.10 meq (milliequivalent) of exchangeable K/100 g of soil was adequate for normal growth. Also, 50 to 75 kg/ha of K per year seemed to be sufficient to maintain this level.

Adams and Pearson *(1)* demonstrated that large applications of N without adequate liming in the humid temperate zone may result in excessive soil acidity accompanied by sharp reductions in exchangeable bases, reduced P availability, and equally sharp increases in soluble Al and Mn.

Adams et al. *(2)* reported that the acidity of a soil profile under Coastal bermudagrass sod had increased to a depth of 120 cm by the end of a five-year period as a result of applications of both 896 and 1,793 kg/ha of N.

Neller and Hutton *(14)*, comparing two rates of labeled P, both surface and sub-surface applied, reported a 9.9 percent maximum uptake of the applied P by Argentine bahiagrass during the first year of application.

Vincente-Chandler et al. *(18)* reported results that demonstrated interactions between applied plant nutrients and nutrient uptake by guineagrass. The application of 448 kg/ha of K increased N uptake by 387 kg over that from the application of 224 kg/ha. Conversely, K uptake was increased by 168 kg when the rate of applied N was elevated from 448 to 560 kg/ha.

Data by Cowling and Lockyer *(10)* demonstrated an interaction among four grasses and three levels of applied N on the percentage recovery of applied N. As an average of three N levels, the order of recovery of N by the grasses, from highest to lowest, was (1) S-37 orchardgrass, (2) S-215 meadow fescue, (3) S-48 timothy, and (4) S-24 perennial ryegrass. An example of the differential response of the grasses was shown by the following comparison: N recovery percentages for ryegrass were 35 and 61 at 90 and 360 kg N/ha, respectively, whereas orchardgrass recovery percentages were 59 and 70 at the same N rates, respectively.

Russell (*16*) stated that excess K in the soil, resulting from overfertilization with K, considerably reduced the amount of other cations taken up by the crop. Potassium tends to correct the harmful effects of excess N, and applications are often required for crops receiving high levels of nitrogen. He further presented examples of the soil's ability to compensate for the loss of a particular nutrient from the soil solution. Since the total amount of nutrients taken up by the crop may be greater than the loss from the soil solution, the solid phase of the soil must be continually supplying the nutrient (pp 442-443).

Baver *(7)* demonstrated the effect of soil pH on K losses by leaching. On a Creedy sandy loam soil, K loss from leaching increased from 20% at a pH of 5.5 to 80% at a 4.5 pH.

Data by Jaworski *(13)* illustrated the relationship between K uptake and exchangeable soil K. The uptake of K was equal to the exchangeable K up to about 160 pounds per acre of K; thereafter, uptake was slightly lower than exchangeable K up to 340 pounds per acre.

Fitts *(11)* presented the probabilities of profitable response from fertilization on soils testing from very low to very high in a nutrient. The probabilities were as follows: very low, 85%; low, 60%; medium, 40%; high, 15%; and very high, 5%.

Barber et al. *(6)* established the approximate amounts of P and K needed to maintain medium and high soil test results for Indiana soils. For crops in which the entire above-ground portion was removed, such as hay or silage, the need for applied nutrients was drastically increased. One-third more plant nutrients were required to maintain high soil test results in soils that otherwise tested low. The amount required was increased by two-thirds in order to maintain high soil test results on soils that tested very low.

Peevy *(15)* reported on the chemical data used to interpret soil test results for silt loam soils of the Loessial Hills, which include the soil type on which this study was conducted. The ratings of extractable elements (ppm) in soils with a cation exchange capacity of 8 milliequivalents were:

	Extractable, ppm			
Rating	P	K	Ca	Mg
Very low	10	60		
Low	10-35	60-100	1,000	100
Medium	35-70	100-140	1,000-1,300	100-130
High	70+	140+	1,300+	130+

EXPERIMENTAL PROCEDURE

The experiment was conducted on Lexington silt loam soil at the Southeast Louisiana Dairy and Pasture Experiment Station, Franklinton, Louisiana. The study was initiated in the fall of 1966 and was continued through the 1970-71 season. Prior cropping history of the experimental site included a six-year study with N rates on cool season annual grasses. Phosphorus and potassium had been applied uniformly at the rate of 140 pounds per acre each as P_2O_5 and K_2O. Two tons of dolomitic limestone per acre had been applied prior to the beginning of the six-year study. That study was followed by two years of varietal testing of cool season grasses which received annual applications of 200 pounds of N and 100 pounds each of P_2O_5 and K_2O per acre.

The cation exchange capacity of the soil was 5.5 milliequivalents per 100 grams of dry soil. Prior to any cropping history the soil contained 3 ppm of extractable P, 42 ppm of extractable K, 181 ppm of extractable Ca, and 87 ppm of extractable Mg. The soil reaction (pH) was 5.0. Soil analyses immediately preceding the initiation of the experiment being reported on showed that the soil contained 28 ppm of extractable P, 45 ppm of extractable K, 720 ppm of extractable Ca, and 137 ppm of extractable Mg. The soil pH was 5.5.

Two tons of dolomitic limestone per acre were applied to the experimental area on August 1, 1966. One ton was plowed under with moldboard plows to a depth of six inches. The other ton was then incorporated into the soil with a disc harrow.

Treatments included three levels each of N (200, 300, and 400 pounds per acre), P (100, 200, and 300 pounds per acre expressed as P_2O_5), and K (100, 200, and 300 pounds per acre expressed as K_2O) which were applied annually in all possible combinations. For base line information, nine additional treatments were included in which one or more of the plant nutrients was not applied.

The fertilizer materials used were ammonium nitrate (33.5% N), triple superphosphate (46% P_2O_5), and muriate of potash (62% K_2O). All of the P and K and one-half of the N were applied broadcast prior to discing and planting. Of the remaining N, one-half was applied in late December and one-half in mid-March as topdressings.

A randomized complete block design with four replications was employed. The overall plot size was 10' x 21'; the fertilized area was 8' x 20', and the harvested area was 4' x 16'. Moregrain oats (*Avena sativa*) were drilled at the rate of 112 pounds per acre, and Gulf ryegrass (*Lolium multiflorum*) was broadcast at the rate of 30 pounds per acre.

The harvest schedule for the first four years was based on the height of the forage. In those years, the plants were clipped to a 4-inch stubble when the forage averaged 12 to 14 inches in height. During the fifth season, harvests were made to a 3-inch stubble height on the first and fifteenth of each month. The total number of harvests in each of the five successive seasons beginning with 1966-67 was 6, 6, 7, 6, and 10, respectively.

The forage was cut with a sickle bar mower and collected in an attached metal tray. Green weights were recorded and sub-samples of the forage were dried at 135°F in a forced-air, thermostatically controlled dryer. The dried samples were ground in a Wiley mill with a 1-mm screen for laboratory analyses.

Determinations of N, P, K, Ca, and Mg concentrations in the forage were made according to A.O.A.C. procedures (*5*). Nutrient removal in pounds per acre was calculated by multiplying the pounds of dry forage per acre by the percentage nutrient in the forage for each plot at each clipping.

Soil samples were collected from each plot in all replications at the end of each growing season. The soil samples were taken to a depth of six inches and stored in plastic bags until analyzed. The analytical methods and procedures used to determine soil reaction and extractable P, K, Ca, and Mg are described in Louisiana Agricultural Experiment Station Bulletin No. 632 *(9)*.

Statistical analyses of the data were conducted according to procedures outlined by Snedecor *(17)*. The data from all replications were pooled within years, and an analysis of variance was conducted for each variable using years as replications. An analysis of variance was conducted using only the 3 x 3 x 3 factorial arrangement of treatments as well as an analysis containing all 36 treatment combinations. All data were recorded by harvest date. A regression analysis of each variable on harvest date, recorded as number of days since the base date of September 1, was conducted where the linear, quadratic, cubic, and quartic terms for harvest date were included. A step-wise regression procedure was employed whereby the coefficient of determination was maximized while only the significant effects of harvest date were retained in the regression equation. Regression analyses were conducted for each level of N, P, and K in the factorial arrangement, and the control treatment (no applied N, P, or K).

The Duncan's New Range Test was used to determine significant differences among treatments in the plant nutrient uptake data and soil analyses data. Coefficients of variation and all possible correlation coefficients were obtained.

RESULTS AND DISCUSSION

Phosphorus, applied as a plant nutrient, and phosphorus removal in the harvested forage are expressed as P_2O_5. The P_2O_5 values were determined by multiplying elemental P values by 2.29. Potassium, applied as a plant nutrient, and potassium removal in the harvested forage are expressed as K_2O. The K_2O values were determined by multiplying elemental K by 1.2. Nitrogen (N), calcium (Ca), and magnesium (Mg) are expressed as elemental values. Extractable P, K, Ca, and Mg in the soil are reported as parts per million (ppm). Soil organic matter values are reported in percent and the soil reaction values are expressed in pH units.

A. Nutrient Removal

Crop removal of N, P_2O_5, K_2O, Ca, and Mg as a season average over all years for the 36 treatment combinations is shown in Table 1. The yearly averages of nutrient removal over all treatments are reported at the bottom of the table. The removal of all nutrients generally increased with increased levels of applied nitrogen. Percentage-wise, removal of Mg was affected to a greater extent by treatments than was removal of the other nutrients.

Uptake of P_2O_5 and K_2O was increased with increased applications of those respective nutrients. Applied K_2O had a negative effect on the uptake of Ca and Mg, while P_2O_5 applications had a positive influence on the uptake of these elements. The uptake of K, Ca, and Mg was affected not only by K_20 applications but also by the level of N used. For example, with the application of 300 pounds of K_2O, approximately 80 pounds

Table 1. Effects of N, P_2O_5, and K_2O applied annually on nutrient removal in the harvested forage of an oat-ryegrass mixture, five-year average

Applied, lbs/a			Nutrient removal, lbs/a				
N	P_2O_5	K_2O	N	P_2O_5	K_2O	Ca	Mg[1]
200	100	100	254^{e}	53^{f}	212^{fg}	28^{f}	19^{h}
200	200	100	276^{h}	68^{k}	217^{gh}	34^{j}	22^{k}
200	300	100	271^{g}	71^{l}	219^{h}	34^{j}	22^{k}
200	100	200	275^{g}	64^{i}	299^{l}	29^{g}	18^{g}
200	200	200	266^{f}	64^{i}	295^{l}	27^{e}	18^{g}
200	300	200	263^{f}	72^{m}	299^{l}	28^{f}	17^{f}
200	100	300	253^{e}	60^{g}	324^{mn}	25^{d}	15^{d}
200	200	300	276^{h}	68^{k}	318^{m}	28^{f}	17^{f}
200	300	300	271^{g}	77^{o}	329^{n}	29^{g}	16^{e}
300	100	100	297^{i}	62^{h}	259^{k}	35^{k}	22^{k}
300	200	100	308^{k}	68^{k}	227^{i}	38^{n}	24^{m}
300	300	100	302^{j}	73^{m}	251^{j}	37^{m}	23^{l}
300	100	200	312^{l}	66^{j}	323^{mn}	33^{i}	21^{j}
300	200	200	328^{o}	77^{o}	348^{o}	35^{k}	23^{l}
300	300	200	316^{m}	82^{q}	329^{n}	34^{j}	22^{k}
300	100	300	312^{l}	66^{j}	370^{p}	32^{h}	20^{i}
300	200	300	308^{k}	80^{p}	353^{o}	32^{h}	20^{i}
300	300	300	321^{n}	85^{r}	398^{r}	34^{j}	21^{j}
400	100	100	316^{m}	64^{i}	211^{f}	40^{o}	24^{m}
400	200	100	343^{p}	73^{m}	259^{k}	41^{p}	26^{o}
400	300	100	367^{t}	85^{r}	255^{jk}	41^{p}	29^{p}
400	100	200	348^{q}	66^{j}	330^{n}	36^{l}	23^{l}
400	200	200	356^{r}	75^{n}	351^{o}	37^{m}	24^{m}
400	300	200	367^{t}	85^{r}	323^{mn}	41^{p}	25^{n}
400	100	300	360^{s}	71^{l}	398^{r}	36^{l}	22^{k}
400	200	300	373^{u}	83^{q}	399^{r}	36^{l}	23^{l}
400	300	300	369^{t}	85^{r}	383^{q}	36^{l}	24^{m}
0	0	0	108^{a}	27^{b}	119^{a}	14^{b}	8^{b}
200	0	0	205^{c}	39^{d}	136^{b}	25^{d}	16^{e}
200	200	0	238^{d}	59^{g}	168^{e}	29^{g}	19^{h}
200	0	200	235^{d}	43^{e}	264^{k}	23^{c}	15^{d}
0	200	0	119^{b}	37^{c}	121^{a}	14^{b}	9^{c}
0	0	200	106^{a}	25^{a}	139^{bc}	12^{a}	6^{a}
0	200	200	120^{b}	37^{c}	162^{d}	14^{b}	8^{b}
300	0	0	236^{d}	43^{e}	143^{c}	29^{g}	19^{h}
400	0	0	234^{d}	38^{d}	134^{b}	27^{e}	17^{f}
Year averages							
1966-67			292^{d}	59^{a}	265^{c}	41^{d}	
1967-68			270^{b}	59^{a}	256^{b}	30^{c}	21^{c}
1968-69			248^{a}	59^{a}	245^{a}	24^{a}	17^{a}
1969-70			280^{c}	73^{c}	284^{d}	29^{b}	20^{b}
1970-71			298^{e}	69^{b}	293^{e}	30^{c}	20^{b}

1 - Four years only.

Means with same letter superscript in columns do not differ significantly at P/.05.

more K_2O were removed at the 400-pound level of applied N than at the 200-pound level of N. This was due in part to increased yield, and probably increased concentration of K in the plants to offset the unbalanced effects resulting from the high N uptake.

The greatest removal of N occurred with the 400-200-300 fertilizer treatment. However, the 300- and 400-pound N applications without added P_2O_5 were no different in N removal than the 200-pound rate of applied N with either P_2O_5 or K_2O in the amount of 200 pounds. Nutrient removal of all five elements studied in the O-O-O plot was approximately one-half that of the 200-100-100 treatment combinations.

Significant year × nutrient uptake interaction occurred for all nutrients evaluated in this study. The greatest uptake of N and K_2O occurred in the 1970-71 season, while P_2O_5 uptake was greatest in the 1969-70 season. The highest levels of uptake of Ca and Mg were noted in the 1966-67 and 1967-68 seasons, respectively. The comparison of Ca and Mg uptake in the fifth season with that in the earlier seasons indicates that these two nutrients had not become deficient enough to decrease plant growth.

1. *Nitrogen Removal*

Table 2 shows the mean effects of applied N, P_2O_5, and K_2O on the removal of N in the forage. Significant increases in N removal were obtained for both levels of N above 200 pounds per acre at all levels of applied P_2O_5 and K_2O. Although applications of P_2O_5 and K_2O resulted in significant increases in N uptake, the numerical differences were relatively small. The effects of increased rates of applied K_2O on N removal became more apparent in combination with increased rates of applied N.

Applied N had a significant effect on the N removal throughout the growing season (Figure 1). Differences in removal among all three rates of applied N were greatest from mid-March to late April. Nitrogen uptake generally showed the same pattern at all levels of applied N over the season. Sharp increases in N uptake during November and March were followed by decreases immediately thereafter. Nitrogen removal in the non-fertilized forage was rather constant at about 20 pounds per acre throughout the season. In contrast, the N-fertilized forage removed from 35 to 70 pounds of N per acre per average harvest date, depending on the level of applied N and time in the season.

2. *P_2O_5 Removal*

Applied N had a small but significant effect on increasing P_2O_5 removal, averaged over all P_2O_5 and K_2O rates (Table 3). The mean effect of increasing the N application from 200 to 400 pounds per acre resulted in the removal of an additional 10 pounds of P_2O_5 per acre.

The applications of 200 and 300 pounds of P_2O_5 increased the uptake

Table 2. Effects of N, P_2O_5, and K_2O applied annually on N removal in the harvested forage of an oat-ryegrass mixture, five-year average

N	P_2O_5, lbs/a			
Lbs/a	100	200	300	Av
	- - - - N removal, lbs/a - - - - -			
200	261^{a1}	272^{a3}	268^{a2}	267^{a}
300	307^{b1}	315^{b2}	314^{b2}	312^{b}
400	341^{c1}	357^{c2}	368^{c3}	355^{c}

P_2O_5	K_2O, lbs/a			
Lbs/a	100	200	300	Av
	- - - - N removal, lbs/a - - - - -			
100	289^{a1}	311^{a3}	308^{a2}	303^{a}
200	309^{b1}	316^{b2}	319^{b3}	315^{b}
300	313^{c1}	315^{b2}	320^{b3}	316^{c}

K_2O	N, lbs/a			
Lbs/a	200	300	400	Av
	- - - - N removal, lbs/a - - - - -			
100	267^{a1}	302^{a2}	342^{a3}	304^{b}
200	268^{a1}	319^{c2}	357^{b3}	314^{b}
300	267^{a1}	314^{b2}	367^{c3}	316^{c}

Means with same letter superscript within columns or same number superscript within rows do not differ significantly at $P \angle .05$.

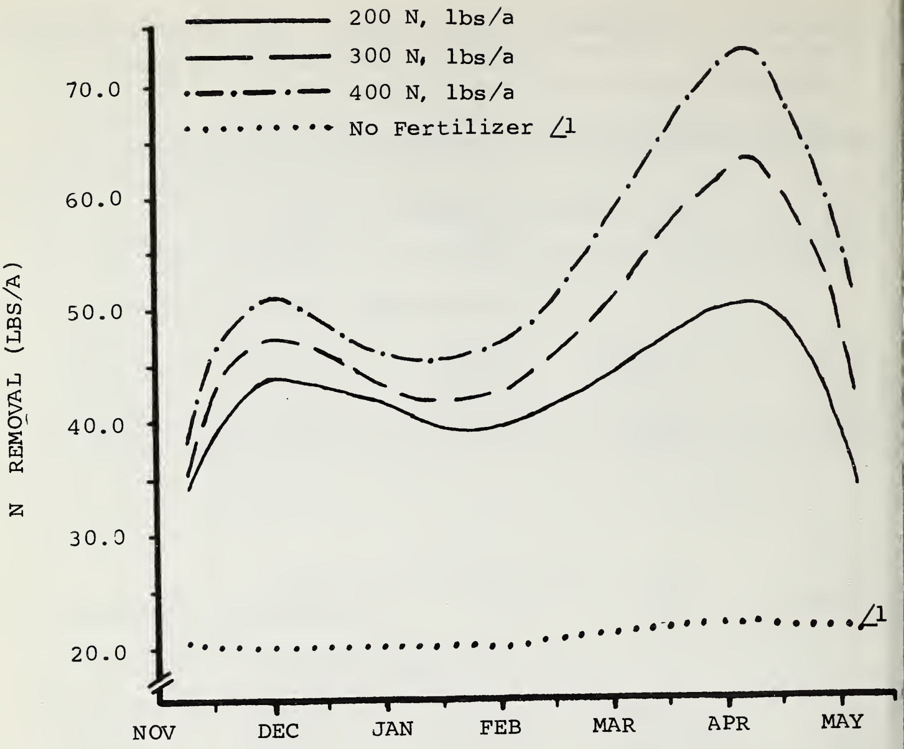

Fig. 1. Effects of season and applied N on the removal of N in the harvested forage of an oat-ryegrass mixture. Average of 7 harvests per year over 5 years.
∠1 Base line information only.

of P_2O_5 over the 100-pound rate by 9 and 6 pounds, respectively. The uptake of P_2O_5 significantly increased by 6 pounds per acre as applied K_2O rates increased from 100 to 300 pounds per acre.

There was a rapid increase in the removal of P_2O_5 at all rates of applied P_2O_5 throughout November and from mid-February until early April (Figure 2). Uptake of P_2O_5 increased nearly twofold from the initial level during the month of November in response to all the applied rates. However, uptake decreased slightly during the midseason at the 200- and 300-pound rates of P_2O_5. Thereafter, uptake increased rapidly from late February to mid-April at all P_2O_5 rates. Removal differences among application rates were greatest in early December and April. Uptake of P_2O_5 in the non-fertilized forage exhibited a definite increase during the season.

Table 3. Effects of N, P_2O_5, and K_2O applied annually on P_2O_5 removal in the harvested forage of an oat-ryegrass mixture, five-year average

N	P_2O_5, lbs/a			
Lbs/a	100	200	300	Av
	- - - P_2O_5 removal, lbs/a - - -			
200	59^{a1}	67^{a2}	74^{a3}	66^{a}
300	66^{b1}	76^{b2}	80^{b3}	74^{b}
400	67^{c1}	77^{b2}	84^{c3}	76^{c}

P_2O_5	K_2O, lbs/a			
Lbs/a	100	200	300	Av
	- - - P_2O_5 removal, lbs/a - - -			
100	60^{a1}	65^{a2}	66^{a2}	64^{a}
200	71^{b1}	73^{b2}	77^{b3}	73^{b}
300	76^{c1}	80^{c2}	82^{c3}	79^{c}

K_2O	N, lbs/a			
Lbs/a	200	300	400	Av
	- - - P_2O_5 removal, lbs/a - - -			
100	64^{a1}	68^{a2}	74^{a3}	69^{a}
200	67^{b1}	76^{b3}	75^{b2}	73^{b}
300	69^{c1}	77^{c2}	79^{c3}	75^{c}

Means with same letter superscript within columns or same number superscript within rows do not differ significantly at $P \angle .05$.

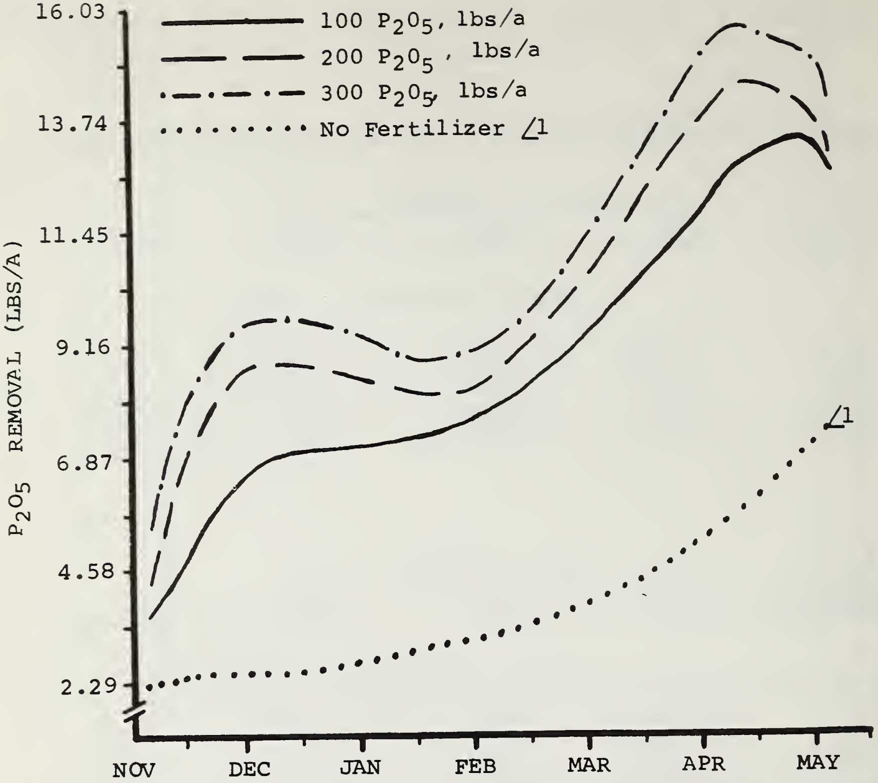

Fig. 2. Effects of season and applied P_2O_5 on the removal of P_2O_5 in the harvested forage of an oat-ryegrass mixture. Average of 7 harvests per year over 5 years.
∠1 Base line information only.

3. K_2O Removal

The uptake of K_2O increased significantly with each increase in applied N (Table 4). Potassium uptake was also increased significantly by P_2O_5 applications, but the increases were relatively small.

Applied K_2O exerted the greatest influence on K_2O removal, followed in descending order by applied N and applied P_2O_5. When K_2O applications increased from 100 to 200 and from 200 to 300 pounds per acre, the uptake of K_2O increased 87 and 41 pounds, respectively.

Figure 3 illustrates that K_2O removal increased in the month of November and from early February to early April, but decreased from early December to early February, and from early April to early May. The trends were the same at all K_2O rates applied. Uptake of K_2O in the non-fertilized forage did not fluctuate significantly throughout the season.

Table 4. Effects of N, P_2O_5, and K_2O applied annually on K_2O removal in the harvested forage of an oat-ryegrass mixture, five-year average

N	P_2O_5, lbs/a			
Lbs/a	100	200	300	Av
	- - - - K_2O removal, lbs/a - - - -			
200	278^{a1}	277^{a1}	282^{a2}	279^{a}
300	317^{c2}	309^{b1}	326^{c3}	317^{b}
400	313^{b1}	337^{c3}	320^{b2}	323^{c}

P_2O_5	K_2O, lbs/a			
Lbs/a	100	200	300	Av
	- - - - K_2O removal, lbs/a - - - -			
100	227^{a1}	317^{a2}	364^{b3}	302^{a}
200	235^{b1}	331^{b2}	357^{a3}	307^{b}
300	242^{c1}	317^{a2}	370^{c3}	309^{c}

K_2O	N, lbs/a			
Lbs/a	200	300	400	Av
	- - - - K_2O removal, lbs/a - - - -			
100	217^{a1}	245^{a2}	242^{a2}	235^{a}
200	297^{b1}	333^{b2}	335^{b2}	322^{b}
300	323^{c1}	373^{c2}	393^{c3}	363^{c}

Means with same letter superscript within columns or same number superscript within rows do not differ significantly at $P \angle .05$.

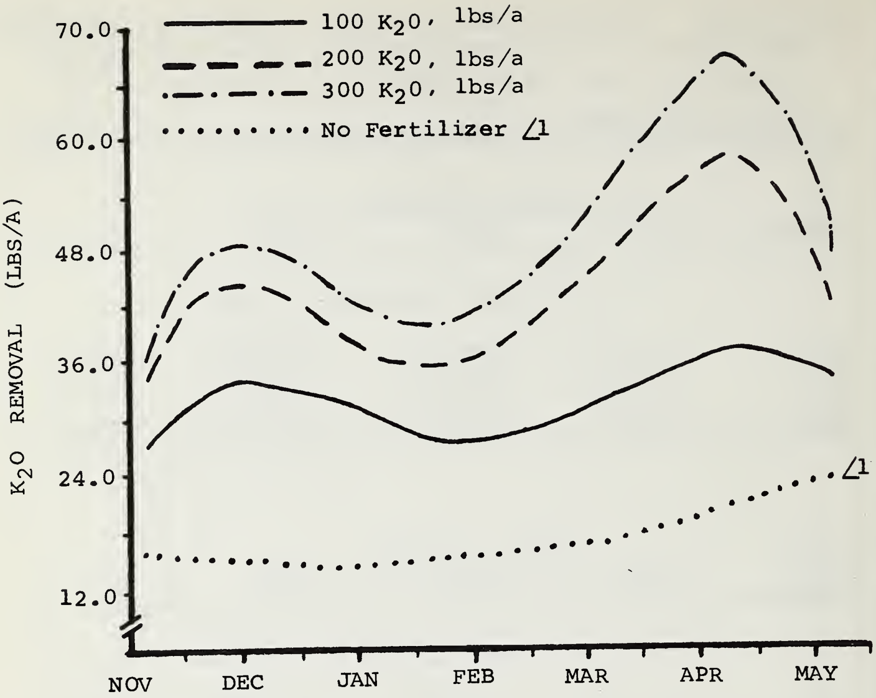

Fig. 3. Effects of season and applied K_2O on the removal of K_2O in the harvested forage of an oat-ryegrass mixture. Average of 7 harvests per year over 5 years.
∠1 Base line information only.

4. Calcium Removal

Calcium removal increased significantly with each 100-pound increase of applied N above the 200-pound rate (Table 5). The application of P_2O_5 increased the Ca removal significantly, but the increases were of small magnitude.

Applied K_2O decreased Ca removal by 2 pounds with each increase in applied K_2O over the 100-pound rate. The decrease in Ca removal as affected by K_2O applications was more than offset by the increase resulting from N applications.

Calcium removal in response to N application increased throughout the season except for a period from early December to mid-January and at the end of the growing season (Figure 4). The greatest difference in Ca removal among N rates occurred in April.

Figure 5 illustrates the seasonal response of Ca removal to K_2O application. Increased rates of applied K_2O decreased Ca removal consistently throughout the entire season. Although not illustrated, the seasonal trend

Table 5. Effects of N, P_2O_5, and K_2O applied annually on Ca removal in the harvested forage of an oat-ryegrass mixture, five-year average

N	P_2O_5, lbs/a			
Lbs/a	100	200	300	Av
	- - - - Ca removal, lbs/a - - - -			
200	27^{a1}	30^{a2}	30^{a2}	29^{a}
300	33^{b1}	35^{b2}	35^{b2}	34^{b}
400	37^{c1}	38^{c2}	40^{c3}	38^{c}

P_2O_5	K_2O, lbs/a			
Lbs/a	100	200	300	Av
	- - - - Ca removal, lbs/a - - - -			
100	34^{a3}	33^{a2}	31^{a1}	33^{a}
200	37^{b3}	33^{a2}	32^{b1}	34^{b}
300	37^{b3}	35^{b2}	33^{c1}	35^{c}

K_2O	N, lbs/a			
Lbs/a	200	300	400	Av
	- - - - Ca removal, lbs/a - - - -			
100	32^{c1}	36^{c2}	40^{c3}	36^{c}
200	28^{b1}	34^{b2}	38^{b3}	34^{b}
300	27^{a1}	33^{a2}	36^{a3}	32^{a}

Means with same letter superscript within columns or same number superscript within rows do not differ significantly at P∠.05.

of Ca removal was similar regardless of the plant nutrients applied. The most rapid uptake of Ca occurred in November and March. Removal of Ca by the non-fertilized forage increased only in the latter half of the growing season.

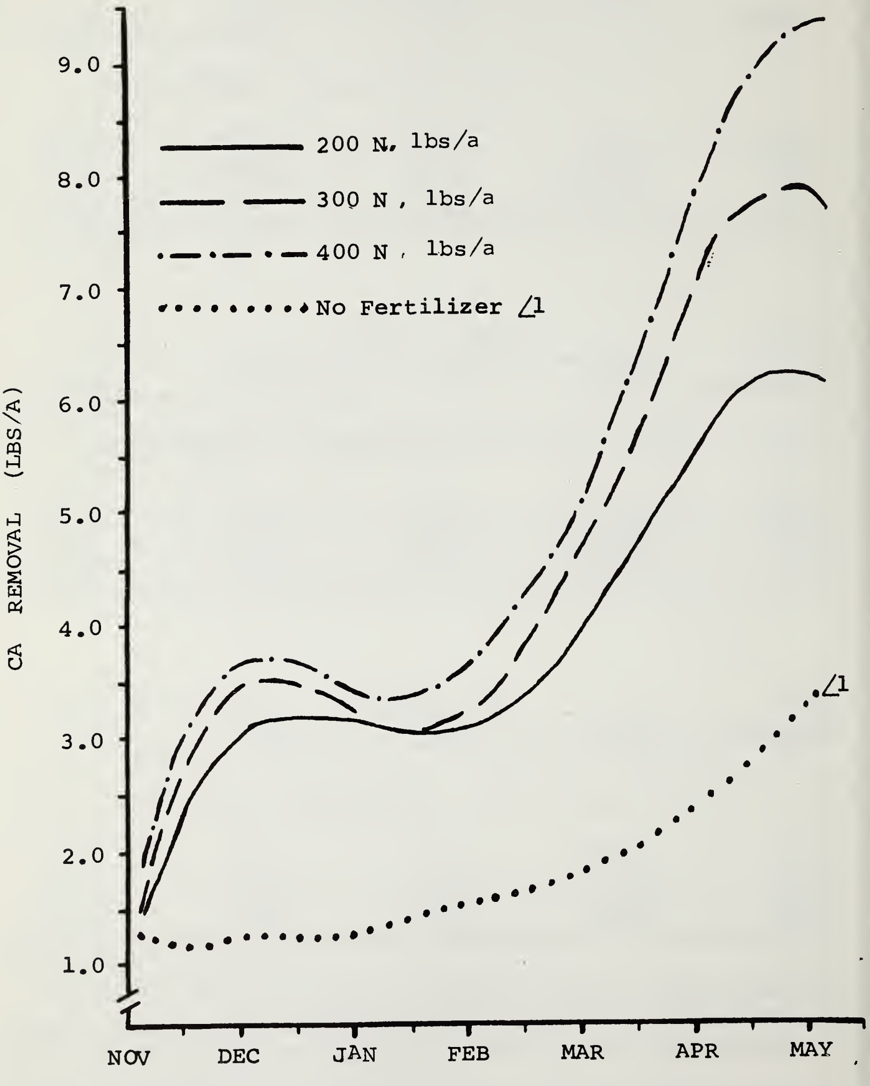

Fig. 4. Effects of season and applied N on the removal of Ca in the harvested forage of an oat-ryegrass mixture. Average of 7 harvests per year over 5 years.
∠1 Base line information only.

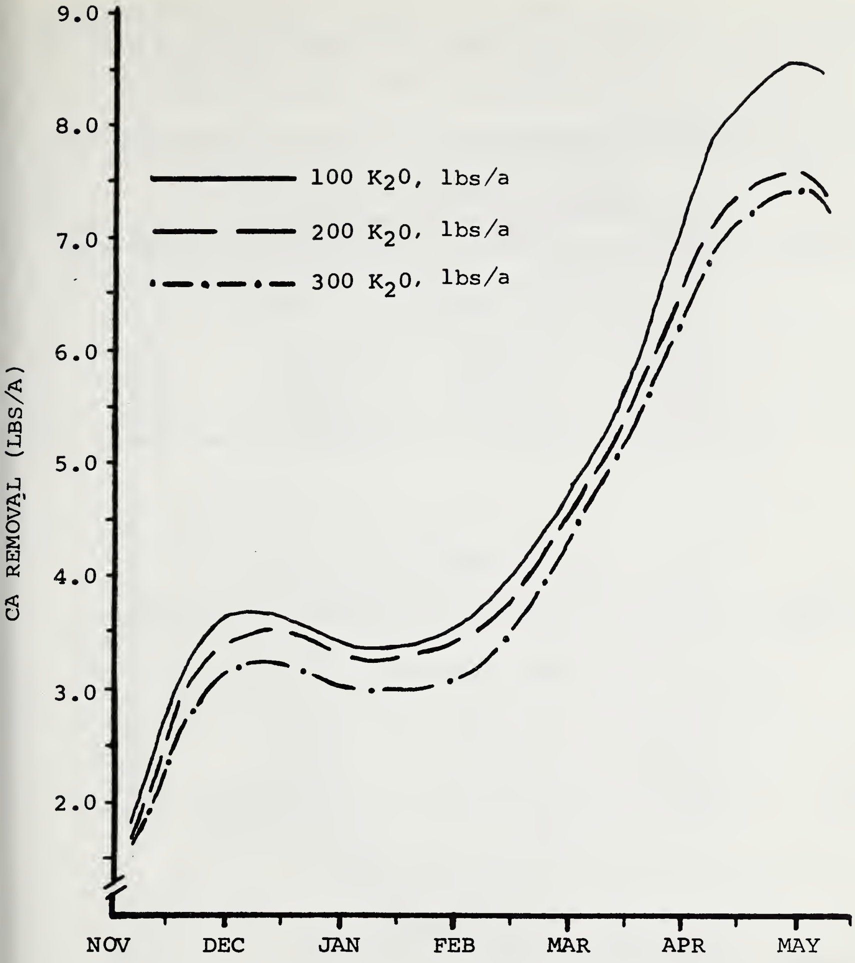

Fig. 5. Effects of season and applied K_2O on the removal of Ca in the harvested forage of an oat-ryegrass mixture. Average of 7 harvests per year over 5 years.

5. *Magnesium Removal*

Nitrogen application significantly increased Mg removal (Table 6). Magnesium removal increased by 4 and 3 pounds per acre, respectively, with each 100-pound increase in applied N above the 200-pound rate. Magnesium removal increased by 2 pounds per acre at both the 200- and 300-pound rates of applied P_2O_5 over that of the 100-pound rate.

The mean effect of applied K_2O on Mg removal was negative and significant but of small magnitude. The positive effect of N fertilization was greater than the negative effect of K_2O fertilization on Mg removal.

Table 6. Effects of N, P_2O_5, and K_2O applied annually on Mg removal in the harvested forage of an oat-ryegrass mixture, five-year average

N	P_2O_5, lbs/a			
Lbs/a	100	200	300	Av
	- - - - Mg removal, lbs/a - - - -			
200	17^{a1}	19^{a3}	18^{a2}	18^{a}
300	21^{b1}	22^{b2}	22^{b2}	22^{b}
400	23^{c1}	24^{c2}	26^{c3}	25^{c}

P_2O_5	K_2O, lbs/a			
Lbs/a	100	200	300	Av
	- - - - Mg removal, lbs/a - - - -			
100	22^{a3}	21^{a2}	19^{a1}	20^{a}
200	24^{b3}	21^{a2}	20^{b1}	22^{b}
300	25^{c2}	21^{a1}	21^{c1}	22^{b}

K_2O	N, lbs/a			
Lbs/a	200	300	400	Av
	- - - - Mg removal, lbs/a - - - -			
100	21^{c1}	23^{c2}	26^{c3}	23^{c}
200	18^{b1}	22^{b2}	24^{b3}	21^{b}
300	16^{a1}	20^{a2}	23^{a3}	20^{a}

Means with same letter superscript within columns or same number superscript within rows do not differ significantly at P∠.05.

Magnesium removal was similar throughout the season at all rates of applied N (Figure 6). The greatest rates of uptake occurred in November and from mid-February to early April. A rapid decline in Mg uptake at all N rates occurred from early April to the end of the season. Magnesium uptake differences among N rates were most pronounced from early March to the end of the season. During that time, Mg removal differences were greater between the 200- and 300-pound rates of applied N than between the 300- and 400-pound rates.

Less pronounced differences in Mg removal occurred in response to K_2O applications than to N applications (Figure 7). There was no seasonal fluctuation in rate of Mg removal in the non-fertilized forage until early April. At that time, Mg uptake in the non-fertilized forage began and continued to increase for the remainder of the season, whereas that in the fertilized forage decreased. The non-fertilized forage removed slightly less than half as much Mg as did the fertilized forage.

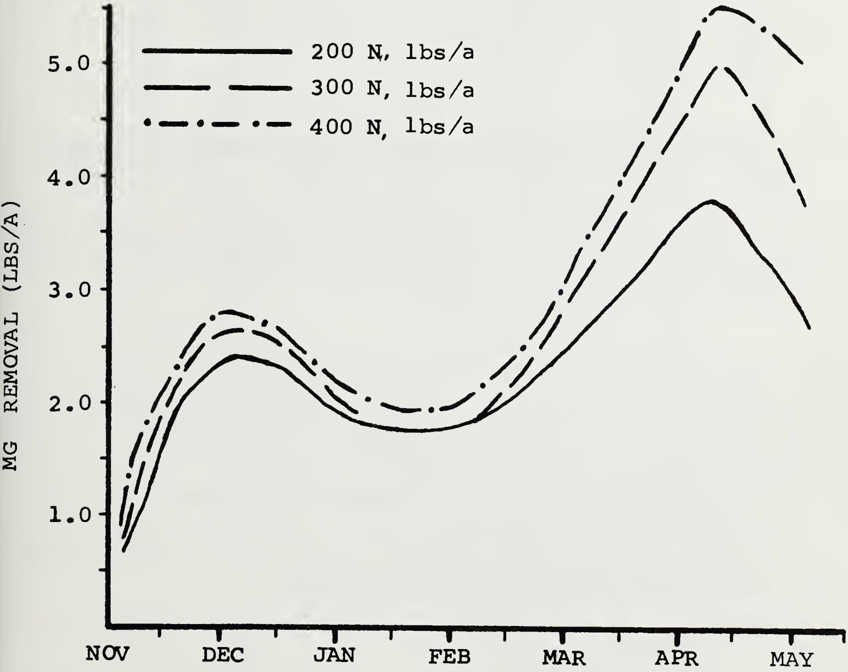

Fig. 6. Effects of season and applied N on the removal of Mg in the harvested forage of an oat-ryegrass mixture. Average of 7 harvests per year over 5 years.

B. Efficiency of Utilization of Applied Nutrients

A study of the uptake of applied plant nutrients can be somewhat academic unless some measure of efficiency of these nutrients relative to forage yield and nutrient content is taken into account. Usually, the

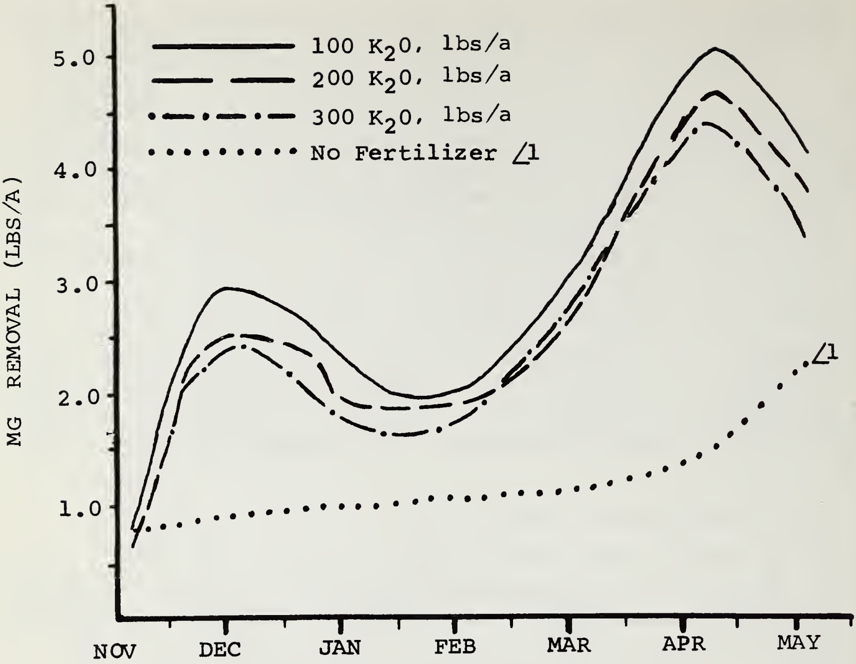

Fig. 7. Effects of season and applied K_2O on the removal of Mg in the harvested forage of an oat-ryegrass mixture. Average of 7 harvests per year over 5 years.
∠1 Base line information only.

efficiency of utilization of a nutrient is determined by comparing the performance of the crop with and without that nutrient applied. Such comparisons aid in an economic evaluation of fertilization for forage production. Normally, a point is reached in forage production beyond which, although yield may continue to increase, the efficiency of utilization of the added nutrient decreases to the extent of being unprofitable.

The efficiency of utilization, expressed in percent, for each applied nutrient was calculated from the following formula:

$$\frac{Ra - Rna}{A} \times 100 = E$$

Where: *Ra* = pounds of plant nutrient removed by the harvested forage with that nutrient applied
Rna = pounds of plant nutrient removed by the harvested forage without that nutrient applied
A = pounds of plant nutrient applied
E = percent efficiency of utilization

The utilization values for all combinations of applied N, P_2O_5, and K_2O are shown in Table 7. Generally, the efficiencies of utilization of the

Table 7. Efficiency of utilization of N, P_2O_5, and K_2O applied annually on an oat-ryegrass mixture, five-yea average

Pounds per acre			Percent utilization		
N	P_2O_5	K_2O	N	P_2O_5	K_2O
200	100	100	67	10	44
200	200	100	78	12	50
200	300	100	75	9	51
200	100	200	77	20	65
200	200	200	73	11	63
200	300	200	71	10	65
200	100	300	66	17	52
200	200	300	78	12	50
200	300	300	75	11	54
300	100	100	59	19	91
300	200	100	63	13	58
300	300	100	61	10	83
300	100	200	64	24	77
300	200	200	69	17	90
300	300	200	65	13	80
300	100	300	64	24	67
300	200	300	63	18	62
300	300	300	67	14	77
400	100	100	49	21	43
400	200	100	56	15	91
400	300	100	62	14	87
400	100	200	57	23	81
400	200	200	59	16	91
400	300	200	62	14	77
400	100	300	60	28	77
400	200	300	63	20	77
400	300	300	62	14	72
0	0	0	-	-	-
200	0	0	48	-	-
200	200	0	65	15	-
200	0	200	63	-	72
0	200	0	-	4	-
0	0	200	-	-	10
0	200	200	-	4	21
300	0	0	43	-	-
400	0	0	31	-	-

applied nutrients decreased as rates of application increased. Applied N and K_2O were utilized more efficiently than was added P_2O_5 at all rates and ratios of the applied nutrients tested. Each nutrient was utilized least efficiently when applied alone. When each nutrient was applied in a complete fertilizer, as compared with being applied singly, the largest increase in utilization was noted for K_2O, followed by P_2O_5 and N. These data reflect the need not only for a complete fertilizer but also for certain ratios of the applied nutrients when the rate of one or more of the nutrients is varied.

1. *Nitrogen Utilization*

The efficiency of utilization of applied N decreased with increased rates of applied N (Table 8). The average N efficiency ranged from 73% at the 200-pound rate of N to 59% at the maximum level of applied N.

Table 8. Effects of N, P_2O_5, and K_2O applied annually on N utilization by an oat-ryegrass mixture, five-year average

N	P_2O_5, lbs/a			
Lbs/a	100	200	300	Av
	% Utilization of N			
200	70	76	74	73
300	62	65	64	64
400	55	59	62	59

P_2O_5	K_2O, lbs/a			
Lbs/a	100	200	300	Av
	% Utilization of N			
100	58	66	63	62
200	66	67	68	67
300	66	66	68	67

K_2O	N, lbs/a			
Lbs/a	200	300	400	Av
	% Utilization of N			
100	73	61	56	63
200	74	66	59	66
300	73	65	62	67

The application of 200 pounds of P_2O_5 improved N utilization consistently over that of 100 pounds of P_2O_5 at all rates of applied N. The application of 300 pounds of P_2O_5 improved the utilization of applied N only in combination with the application of 400 pounds of N per acre.

As an average, the application of 200 pounds of K_2O increased N utilization over that of 100 pounds, with no substantial additional increase when 300 pounds of K_2O were applied.

2. P_2O_5 *Utilization*

Applied P_2O_5 was less efficiently utilized by the crop mixture than were applied N and K_2O, probably because of the rapidity with which phosphorus is bound in an unavailable form in the soil. However, as evidenced in Table 9, P_2O_5 utilization efficiency can be altered by varying the rates and ratios of all three major plant nutrients.

Efficiency of P_2O_5 utilization increased from 13% where 200 pounds of N were applied to 18% where the N rate was 400 pounds per acre.

Phosphorus utilization decreased from 21% to 12% as the applied P_2O_5 increased from 100 to 300 pounds per acre.

Fertilization with K_2O increased P_2O_5 utilization efficiency. The increases were relatively small but uniform as the applied K_2O rates increased from 100 to 300 pounds per acre.

3. K_2O *Utilization*

Nitrogen application increased the utilization efficiency of applied K_2O (Table 10). There was little difference in the mean effect between additions of 300 and 400 pounds of N per acre on efficiency of K_2O utilization. However, the mean difference in the utilization of K_2O was 21 percentage units as N fertilization increased from 200 to 300 pounds per acre.

As an average, the efficiency of utilization of K_2O was elevated by increasing the P_2O_5 rate of application from 100 to 200 pounds per acre.

The mean utilization efficiency of K_2O was increased by the application of 200 pounds of K_2O per acre over the 100-pound rate. The 100- and 300-pound rates of applied K_2O resulted in nearly the same efficiency of K_2O utilization.

C. Correlations

All possible correlation coefficients among per acre forage yield and pounds per acre of N, P_2O_5, K_2O, Ca, and Mg removed in the harvested forage are reported in Table 11. All correlations were positive and highly significant ($P < .01$). These data indicate that with the nutrients in adequate supply, the result was increased forage yield, at least with the rates of applied nutrients tested. Consequently, as yield increased, nutrient removal in the harvested forage increased.

Table 9. Effects of N, P_2O_5, and K_2O applied annually on P_2O_5 utilization by an oat-ryegrass mixture, five-year average

N Lbs/a	P_2O_5, lbs/a 100	200	300	Av
	% Utilization of P_2O_5			
200	16	12	10	13
300	22	16	12	17
400	24	17	14	18

P_2O_5 Lbs/a	K_2O, lbs/a 100	200	300	Av
	% Utilization of P_2O_5			
100	17	22	23	21
200	13	15	17	15
300	11	12	13	12

K_2O Lbs/a	N, lbs/a 200	300	400	Av
	% Utilization of P_2O_5			
100	10	14	17	14
200	14	18	18	16
300	13	19	21	18

Table 10. Effects of N, P_2O_5, and K_2O applied annually on K_2O utilization by an oat-ryegrass mixture, five-year average

N	P_2O_5, lbs/a			
Lbs/a	100	200	300	Av
	% Utilization of K_2O			
200	54	54	57	55
300	78	70	80	76
400	64	86	79	77

P_2O_5	K_2O, lbs/a			
Lbs/a	100	200	300	Av
	% Utilization of K_2O			
100	59	74	65	66
200	66	81	63	70
300	74	74	68	72

K_2O	N, lbs/a			
Lbs/a	200	300	400	Av
	% Utilization of K_2O			
100	48	77	74	66
200	64	82	83	76
300	52	69	75	65

Table 11. Correlation coefficients between forage yield and nutrient removal in the harvested forage of an oat-ryegrass mixture. Average of 7 clippings per year over 5 years

	Nutrient removal, lbs/a[1]				
	N	P_2O_5	K_2O	Ca.	Mg[2]
Yield	.80	.85	.74	.92	.93
N		.83	.84	.76	.86
P_2O_5			.79	.80	.87
K_2O				.61	.70
Ca					.95

[1] All correlations are significant at $P \angle .01$ level of probability.

[2] Four years only.

Yield was more closely correlated with level of removal of N and P_2O_5 than with K_2O. The relationship between yield and K_2O removal was probably lowered to some extent by "luxury consumption" of K_2O in the plants, particularly during the early part of the growing season. Yield was most closely associated with Ca and Mg removal. This implies that an oat-ryegrass mixture has the potential for maintaining relatively high Ca and Mg contents when these nutrients are adequately available, thus maintaining a mineral balance essential for proper animal nutrition.

The correlations of N removal with those of P_2O_5, K_2O, and Mg were practically the same, whereas there was a slightly lower correlation between N and Ca removal. The removal of P_2O_5 was more closely related to Mg than to K_2O or Ca removal. The association between K_2O and Ca removal was the lowest, while that of Ca and Mg removal was highest among the 15 correlation coefficients obtained.

D. Soil Analyses

Chemical analyses of soil samples taken annually from soils with known fertilizer applications and yield aid in interpreting and evaluating experimental data as a basis for fertilizer recommendations. Improper ratios and levels of fertilizer applications may result in a depletion of certain plant nutrients or an accumulation of one or more nutrients. In either case, an unbalanced condition would exist among plant nutrients in the soil. The excess or deficiency of one or more nutrients may also affect the availability of minor elements that can be toxic to plants and/or animals.

1. *Extractable Phosphorus*

Soil analyses data are reported in two-way summary tables by years to help demonstrate the accumulative effects of fertilizer treatments. The extractable P as affected by applied P_2O_5 and K_2O, averaged over applied N rates, is shown in Table 12. Significant increases in extractable P were obtained with increases in applied P_2O_5 above the 100-pound per acre rate. This increase in response to applied P_2O_5 occurred at all levels of applied K_2O, indicating that K_2O had no appreciable effect on extractable P content. At the 100-pound rate of applied P_2O_5, there was no significant increase in extractable P over the five years reported. However, as the rate of applied P_2O_5 increased, the amount of extractable P increased proportionately. Generally, the increase in extractable P occurred after the third season at the 200-pound rate of P_2O_5, and after the first season at the 300-pound rate of applied P_2O_5. Among years, extractable P was highest in 1970. This may have been due, in part, to lower soil moisture during the sampling period, resulting in less effective sampling to the 6-inch depth.

On soils similar to the one used in this experiment, extractable P below 35 ppm is considered low with regard to availability of P to plants. A range of 35 to 70 ppm of P is rated medium in availability, and values above 70 ppm are rated high. Extractable P values above 81 ppm are characterized as very high. At the termination of the experiment, extractable P was in the category of medium in availability where 100 pounds of P_2O_5 per acre were applied annually. The extractable P increased to the very high category of availability at both the 200- and 300-pound per acre applications.

The effects of applied N and K_2O on extractable P content are shown in Tables 19 and 20, respectively (Appendix).

2. *Extractable Potassium*

As presented in Table 13, the extractable K content of the soil increased significantly with each increase in applied K_2O over 100 pounds per acre, as an average over all years. At the 100-pound rate of applied K_2O, there was no significant effect of varying nitrogen rates on the extractable K content of the soil. However, as N rate increased, the extractable K content decreased significantly at the 200- and 300-pound rates of applied K_2O. The mean level of extractable K was highest, 90 ppm, in a combination of 200 pounds of N and 300 pounds of K_2O.

Less than 60 ppm of extractable K in the soil is characterized as very low with regard to K availability to plants. A range of 60 to 100 ppm of K is rated low in availability. In this study, although the extractable K content was increased significantly by K_2O fertilization, the K levels remained in the very low to low ranges.

Extractable K content decreased significantly as N applications increased from 200 to 400 pounds per acre (Table 21, Appendix).

Table 12. Effects of P_2O_5 and K_2O applied annually to an oat-ryegrass mixture on extractable P

	P_2O_5, lbs/a with 100 lbs/a K_2O			
Year	100	200	300	Av
	P, ppm			
1967	66^{a1}	75^{a1}	80^{a1}	74^{1}
1968	50^{a1}	83^{b1}	105^{c2}	79^{12}
1969	56^{a1}	83^{b1}	117^{c2}	85^{2}
1970	68^{a1}	105^{b2}	150^{c3}	108^{3}
1971	62^{a1}	88^{b1}	113^{c2}	87^{2}
Av	60^{a1}	85^{b1}	113^{c1}	87^{1}

	P_2O_5, lbs/a with 200 lbs/a K_2O			
Year	100	200	300	Av
	P, ppm			
1967	62^{a1}	70^{a1}	86^{b1}	73^{1}
1968	59^{a1}	77^{b1}	98^{c1}	78^{1}
1969	60^{a1}	86^{b1}	127^{c2}	91^{2}
1970	70^{a1}	103^{b2}	143^{c3}	106^{3}
1971	62^{a1}	86^{b1}	120^{c2}	89^{2}
Av	63^{a1}	84^{b1}	115^{c1}	87^{1}

	P_2O_5, lbs/a with 300 lbs/a K_2O			
Year	100	200	300	Av
	P, ppm			
1967	52^{a1}	76^{b1}	90^{b1}	73^{1}
1968	56^{a1}	81^{b1}	106^{c2}	81^{1}
1969	54^{a1}	74^{b1}	106^{c2}	78^{1}
1970	67^{a1}	102^{b2}	149^{c4}	106^{3}
1971	59^{a1}	90^{b12}	125^{c3}	91^{2}
Av	57^{a1}	85^{b1}	115^{c1}	86^{1}

Means with same letter superscript within rows or same number superscript within columns do not differ significantly at P/.05.

Table 13. Effect of N and K_2O applied annually to an oat-ryegrass mixture on extractable K

Year	K_2O, lbs/a with 200 lbs N/a			
	100	200	300	Av
	K, ppm			
1967	44^{a1}	47^{ab1}	52^{b1}	48^{1}
1968	44^{a1}	59^{b2}	82^{c2}	62^{2}
1969	38^{a1}	60^{b2}	96^{c3}	65^{2}
1970	34^{a1}	66^{b2}	119^{c4}	73^{3}
1971	38^{a1}	83^{b3}	98^{c3}	73^{3}
Av	$39^{a\mathrm{I}}$	$63^{b\mathrm{III}}$	$90^{c\mathrm{III}}$	64^{III}

Year	K_2O, lbs/a with 300 lbs N/a			
	100	200	300	Av
	K, ppm			
1967	40^{a1}	42^{a1}	52^{b1}	44^{1}
1968	40^{a1}	50^{b1}	66^{c2}	52^{2}
1969	32^{a1}	52^{b1}	76^{c2}	53^{2}
1970	39^{a1}	50^{a1}	96^{b3}	62^{3}
1971	32^{a1}	54^{b1}	76^{c2}	54^{2}
Av	$37^{a\mathrm{I}}$	$50^{b\mathrm{II}}$	$73^{c\mathrm{II}}$	53^{II}

Year	K_2O, lbs/a with 400 lbs N/a			
	100	200	300	Av
	K, ppm			
1967	37^{a1}	38^{ab1}	42^{b1}	39^{1}
1968	40^{a1}	45^{a1}	57^{b2}	47^{2}
1969	31^{a1}	40^{a1}	62^{b2}	45^{2}
1970	34^{a1}	44^{a1}	66^{b2}	48^{2}
1971	36^{a1}	49^{ab1}	57^{b2}	47^{2}
Av	$36^{a\mathrm{I}}$	$43^{b\mathrm{I}}$	$57^{c\mathrm{I}}$	45^{I}

Means with same letter superscript within rows or same number superscript within columns do not differ significantly at $P \leq .05$.

3. *Extractable Calcium*

The data presented in Table 14 indicate that increased N rates generally decreased the extractable Ca content of the soil. There was a fairly consistent decrease in the Ca content during the five-year duration of the study.

The effects of applied P_2O_5 and K_2O on extractable Ca were somewhat erratic and generally not significant (Tables 23 and 24 respectively, Appendix).

4. *Extractable Magnesium*

The effects of applied N and P_2O_5, averaged over K_2O rates, on the extractable soil Mg are shown in Table 15. At each level of applied P_2O_5, the soil Mg content decreased significantly with each increase of applied N over the 200-pound per acre rate. Extractable Mg declined significantly throughout the course of the experiment. The soil Mg level decreased over the five-year period, on the average, about 70 ppm.

As evident from data in Table 26 (Appendix), the soil Mg content was reduced significantly when rates of K_2O increased from 100 to 300 pounds in combination with 200 pounds of N. At the higher rates of N, K_2O application did not significantly change the Mg content.

5. *Soil Reaction (pH)*

Soil reaction (pH) is probably the most important laboratory measurement in evaluating the fertility and lime status of a soil. This is due, in part, to the influence of pH on the availability of plant nutrients. There is generally a positive relationship between pH and lime application, and a negative relationship between pH and N application when acid forming N sources are used.

The pH levels declined significantly with each increase in N application above 200 pounds per acre (Table 16). The decrease in pH was greater between 300 and 400 pounds than between 200 and 300 pounds of applied N.

It is evident from the data that the reaction of the limestone did not peak until the second year. Thereafter, pH declined significantly each year for the remainder of the study. In successive years following 1968, there was an annual decrease in pH level of approximately 0.65, 0.50, and 0.15 unit, respectively, when averaged over all rates of applied N.

The application of P_2O_5 did not influence the soil pH level (Table 27, Appendix). Applications of K_2O resulted in some small but erratic changes in pH (Table 28, Appendix).

Table 14. Effects of N and P_2O_5 applied annually to an oat-ryegrass mixture on extractable Ca

	N, lbs/a with 100 lbs P_2O_5/a			
Year	200	300	400	Av
	Ca, ppm			
1967	634^{a2}	559^{a1}	502^{a2}	565^{3}
1968	581^{b12}	546^{ab1}	484^{a12}	537^{23}
1969	560^{b12}	488^{a1}	446^{a12}	498^{12}
1970	511^{b1}	467^{ab1}	389^{a1}	456^{1}
1971	545^{c12}	472^{b1}	383^{a1}	467^{1}
Av	566^{c11}	506^{b1}	441^{a1}	505^{1}

	N, lbs/a with 200 lbs P_2O_5/a			
Year	200	300	400	Av
	Ca, ppm			
1967	542^{a1}	512^{a1}	484^{a12}	513^{23}
1968	545^{a1}	519^{a1}	512^{a2}	525^{3}
1969	492^{a1}	466^{a1}	438^{a12}	466^{12}
1970	497^{b1}	449^{ab1}	395^{a1}	447^{1}
1971	493^{a1}	463^{a1}	427^{a12}	461^{12}
Av	514^{b1}	482^{ab1}	451^{a1}	482^{1}

	N, lbs/a with 300 lbs P_2O_5/a			
Year	200	300	400	Av
	Ca, ppm			
1967	592^{a1}	482^{a1}	488^{a1}	521^{1}
1968	583^{b1}	503^{ab1}	484^{a1}	524^{1}
1969	552^{b1}	480^{a1}	453^{a1}	495^{1}
1970	552^{b1}	442^{a1}	399^{a1}	465^{1}
1971	557^{b1}	457^{a1}	449^{a1}	487^{1}
Av	567^{b1}	473^{a1}	455^{a1}	498^{1}

Means with same letter superscript within rows or same number superscript within columns do not differ significantly at P/.05.

Table 15. Effects of N and P_2O_5 applied annually to an oat-ryegrass mixture on extractable Mg

	N, lbs/a with 100 lbs P_2O_5/a			
Year	200	300	400	Av
	Mg, ppm			
1967	207^{b4}	188^{ab4}	165^{a4}	187^{4}
1968	181^{c3}	163^{b3}	145^{a3}	163^{3}
1969	165^{b23}	149^{ab23}	132^{a23}	149^{2}
1970	159^{c2}	140^{b2}	119^{a1}	139^{2}
1971	135^{b1}	114^{a1}	103^{a1}	117^{1}
Av	169^{c11}	151^{b1}	133^{a1}	151^{1}

	N, lbs/a with 200 lbs P_2O_5/a			
Year	200	300	400	Av
	Mg, ppm			
1967	194^{b3}	189^{b4}	163^{a3}	182^{4}
1968	170^{b2}	160^{ab3}	150^{a23}	160^{3}
1969	153^{b2}	142^{ab23}	133^{a2}	143^{2}
1970	152^{b2}	136^{ab2}	118^{a1}	135^{2}
1971	123^{b1}	111^{ab1}	103^{a1}	112^{1}
Av	158^{c1}	148^{b1}	133^{a1}	146^{1}

	N, lbs/a with 300 lbs P_2O_5/a			
Year	200	300	400	Av
	Mg, ppm			
1967	211^{b3}	179^{a4}	171^{a4}	187^{4}
1968	172^{b2}	158^{ab3}	146^{a3}	159^{3}
1969	161^{b2}	143^{ab23}	132^{a23}	146^{2}
1970	154^{b2}	134^{a2}	121^{a1}	136^{2}
1971	135^{b1}	112^{a1}	103^{a1}	117^{1}
Av	167^{c11}	145^{b1}	135^{a1}	149^{1}

Means with same letter superscript within rows or same number superscript within columns do not differ significantly at P/.05.

Table 16. Effects of N and P_2O_5 applied annually to an oat-ryegrass mixture on soil reaction (pH)

	N, lbs/a with 100 lbs P_2O_5/a			
Year	200	300	400	Av
	----------pH----------			
1967	5.71^{b3}	5.62^{ab3}	5.42^{a2}	5.58^{3}
1968	6.29^{b4}	6.26^{b4}	6.07^{a3}	6.21^{4}
1969	5.75^{b3}	5.60^{b3}	5.37^{a2}	5.57^{3}
1970	5.22^{c2}	5.07^{b2}	4.83^{a1}	5.04^{2}
1971	5.02^{b1}	4.88^{b1}	4.66^{a1}	4.86^{1}
Av	5.60^{c1}	5.49^{b1}	5.27^{a1}	5.45^{1}

	N, lbs/a with 200 lbs P_2O_5/a			
Year	200	300	400	Av
	----------pH----------			
1967	5.62^{a2}	5.57^{a2}	5.41^{a2}	5.53^{3}
1968	6.22^{a3}	6.21^{a3}	6.07^{a3}	6.17^{4}
1969	5.59^{b2}	5.52^{ab2}	5.37^{a2}	5.49^{3}
1970	5.13^{b1}	5.04^{b1}	4.85^{a1}	5.01^{2}
1971	5.02^{b1}	4.94^{ab1}	4.74^{a1}	4.90^{1}
Av	5.52^{b1}	5.46^{b1}	5.29^{a1}	5.42^{1}

	N, lbs/a with 300 lbs P_2O_5/a			
Year	200	300	400	Av
	----------pH----------			
1967	5.70^{a2}	5.57^{a2}	5.46^{a2}	5.57^{3}
1968	6.27^{b3}	6.21^{b3}	6.03^{a3}	6.17^{4}
1969	5.72^{b2}	5.54^{a2}	5.40^{a2}	5.55^{3}
1970	5.21^{b1}	5.03^{a1}	4.92^{a1}	5.05^{2}
1971	5.08^{b1}	4.87^{ab1}	4.75^{a1}	4.90^{1}
Av	5.59^{c1}	5.44^{b1}	5.31^{a1}	5.45^{1}

Means with same letter superscript within rows or same number superscript within columns do not differ significantly at P/.05.

6. Organic Matter

Soil organic matter content is generally considered to be a good index to the productivity and tilth of a soil. Upland soils with an organic matter content of less than 1.0% are regarded as approaching the critical level for the maintenance of good soil structure.

Laboratory determinations of organic matter content were made in the years 1969 through 1971. The data are presented in Tables 29, 30, and 31 (Appendix). There were no consistent effects of applied N, P_2O_5, or K_2O on the organic matter content of the soil. There was a significant overall decline of about 0.30% organic matter in 1970 as compared with 1969. No further reduction in organic matter content was noted in 1971.

7. Base Line Information

Extractable P, K, Ca, and Mg, soil pH, and organic matter content values resulting from base line fertilizer combinations are presented in Table 17.

The application of 200 pounds of P_2O_5, either with or without added N or K_2O, resulted in higher extractable P content than the fertilizer combinations that excluded applied P_2O_5. Surprisingly, extractable P was not significantly lowered over the duration of the study on plots that did not receive applications of P_2O_5.

Extractable K content increased significantly with the application of 200 pounds of K_2O per acre in the absence of applied N. The application of N significantly lowered the extractable K level, whether with or without applied K_2O. The K level was lower on plots that received only N than on plots that were not fertilized.

The most pronounced decline in extractable Ca and Mg occurred at the maximum rate of applied N, mainly in the 1971 season.

The treatment combinations associated with the lowest soil pH values were those that included N. The pH values began to decline in the third season for all the base line treatments. This decline continued, generally, through the fifth season.

Table 17. Effects of N, P_2O_5, and K_2O applied annually to an oat-ryegrass mixture on soil test results

Lbs/a			Extractable phosphorus, ppm				
			Year				
N	P_2O_5	K_2O	1967	1968	1969	1970	1971
0	0	0	56^{abc1}	42^{ab1}	45^{a1}	47^{a1}	41^{a1}
200	0	0	48^{abc1}	35^{a1}	35^{a1}	36^{a1}	25^{a1}
200	200	0	68^{bc1}	69^{bc1}	80^{b1}	86^{b1}	77^{b1}
200	0	200	39^{a1}	36^{a1}	33^{a1}	40^{a1}	29^{a1}
0	200	0	70^{c1}	82^{c12}	89^{b12}	109^{b2}	103^{c2}
0	0	200	36^{a1}	33^{a1}	37^{a1}	37^{a1}	38^{a1}
0	200	200	49^{abc1}	77^{c2}	93^{b23}	110^{b3}	80^{bc2}
300	0	0	41^{a1}	42^{ab1}	41^{a1}	41^{a1}	41^{a1}
400	0	0	44^{ab1}	37^{a1}	33^{a1}	36^{a1}	34^{a1}

Lbs/a			Extractable potassium, ppm				
			Year				
N	P_2O_5	K_2O	1967	1968	1969	1970	1971
0	0	0	55^{bc1}	54^{bc1}	39^{a1}	46^{a1}	52^{abc1}
200	0	0	39^{a1}	34^{a1}	37^{a1}	31^{a1}	24^{a1}
200	200	0	47^{ab1}	50^{abc1}	30^{a1}	31^{a1}	30^{ab1}
200	0	200	46^{ab1}	66^{c2}	44^{a1}	75^{b2}	69^{c2}
0	200	0	50^{b1}	41^{ab1}	41^{a1}	46^{a1}	56^{bc1}
0	0	200	71^{d1}	115^{d2}	97^{b2}	163^{c3}	170^{d3}
0	200	200	65^{cd1}	120^{d2}	112^{b2}	161^{c3}	163^{d3}
300	0	0	42^{ab1}	36^{a1}	27^{a1}	36^{a1}	31^{ab1}
400	0	0	37^{a1}	34^{a1}	25^{a1}	31^{a1}	40^{ab1}

Lbs/a			Extractable calcium, ppm				
			Year				
N	P_2O_5	K_2O	1967	1968	1969	1970	1971
0	0	0	607^{a1}	565^{a1}	595^{b1}	570^{a1}	600^{bc1}
200	0	0	577^{a1}	585^{a1}	530^{ab1}	507^{a1}	550^{abc1}
200	200	0	597^{a1}	627^{a1}	520^{ab1}	562^{a1}	610^{c1}
200	0	200	535^{a1}	475^{a1}	422^{a1}	422^{a1}	470^{ab1}
0	200	0	580^{a1}	505^{a1}	532^{ab1}	552^{a1}	600^{bc1}
0	0	200	647^{a1}	565^{a1}	512^{ab1}	522^{a1}	610^{c1}
0	200	200	510^{a1}	557^{a1}	502^{ab1}	527^{a1}	570^{abc1}
300	0	0	535^{a1}	560^{a1}	512^{a1}	475^{a1}	500^{abc1}
400	0	0	487^{a1}	475^{a1}	477^{ab1}	465^{a1}	440^{a1}

(continued)

Table 17. (Continued)

Lbs/a			Extractable magnesium, ppm Year				
N	P_2O_5	K_2O	1967	1968	1969	1970	1971
0	0	0	251^{b3}	202^{b2}	184^{c12}	197^{c2}	159^{c1}
200	0	0	207^{ab3}	186^{ab23}	167^{bc12}	173^{bc12}	145^{bc1}
200	200	0	207^{ab3}	187^{ab23}	170^{bc12}	173^{bc12}	149^{bc1}
200	0	200	184^{a3}	162^{a23}	149^{ab1}	146^{ab1}	127^{ab1}
0	200	0	206^{a3}	174^{ab123}	172^{bc12}	180^{bc23}	143^{bc1}
0	0	200	208^{ab2}	185^{ab2}	175^{bc12}	176^{bc12}	148^{bc1}
0	200	200	195^{a2}	170^{ab12}	162^{abc12}	172^{bc12}	139^{bc1}
300	0	0	198^{a3}	171^{ab23}	147^{ab12}	156^{ab12}	127^{ab1}
400	0	0	170^{a3}	153^{a23}	132^{a12}	132^{a12}	103^{a1}

Lbs/a			Soil reaction (pH) Year				
N	P_2O_5	K_2O	1967	1968	1969	1970	1971
0	0	0	5.80^{a2}	6.30^{b3}	5.72^{bc12}	5.40^{d1}	5.32^{c1}
200	0	0	5.77^{a2}	6.45^{b3}	5.72^{bc2}	5.15^{bcd1}	5.25^{c1}
200	200	0	5.82^{a2}	6.30^{b3}	5.67^{bc2}	5.17^{bcd1}	4.92^{abc1}
200	0	200	5.52^{a2}	6.17^{ab3}	5.55^{ab2}	5.00^{abc1}	4.80^{ab1}
0	200	0	5.75^{a2}	6.22^{b3}	5.67^{bc2}	5.35^{d1}	5.02^{bc1}
0	0	200	5.87^{a2}	6.42^{b3}	5.85^{c2}	5.27^{d1}	5.27^{c1}
0	200	200	5.65^{a2}	6.27^{b3}	5.65^{bc2}	5.32^{d1}	5.12^{bc1}
300	0	0	5.47^{a2}	6.10^{ab3}	5.57^{ab2}	4.80^{a1}	4.77^{ab1}
400	0	0	5.57^{a2}	5.85^{a3}	5.35^{a2}	4.92^{ab1}	4.60^{a1}

Lbs/a			Soil organic matter, % Year		
N	P_2O_5	K_2O	1969	1970	1971
0	0	0	1.74^{a1}	1.48^{a1}	1.44^{ab1}
200	0	0	1.79^{a2}	1.38^{a1}	1.38^{a1}
200	200	0	1.70^{a2}	1.41^{a1}	1.44^{ab1}
200	0	200	1.78^{a2}	1.53^{a1}	1.62^{b12}
0	200	0	1.66^{a2}	1.40^{a1}	1.43^{ab1}
0	0	200	1.77^{a2}	1.29^{a1}	1.39^{ab1}
0	200	200	1.76^{a2}	1.26^{a1}	1.35^{a1}
300	0	0	1.75^{a2}	1.41^{a1}	1.50^{ab1}
400	0	0	1.82^{a2}	1.41^{a1}	1.54^{ab1}

Means with same letter superscript within columns or same number superscript within rows do not differ significantly at $P \leq .05$.

E. Correlation Coefficients

All possible correlation coefficients among total forage yield, quantities of five plant nutrients in the harvested forage, and laboratory analytical values of soil samples are reported by years and as a five-year average in Table 18.

Removal of each plant nutrient was positively and significantly correlated with yield in all five years, with the exception of Ca in 1970. However, over years, forage yield was most closely associated with Ca removal. Within years, forage yield was more highly correlated with N removal than with removal of the other nutrients.

Within years, extractable Ca and Mg and pH were negative and more highly correlated with yield than were extractable P and K. Over years, the only significant positive relationship between yield and laboratory soil values occurred with extractable Mg. The magnitude of this correlation ($r=.30$) indicated that about 9% of the variation in yield could be accounted for by differences in the level of Mg in the soil. The only other significant relationship between yield and extractable nutrients over years involved K; this association was negative.

Over years, highly significant positive correlations occurred between N removal and the removal of P, K, Ca, and Mg. The level of N removal in harvested forage was negatively associated with extractable K, Ca, and Mg contents and with soil pH. These negative relationships probably were due to the fact that N removal and N applications were positively associated with forage yield, yet increasing the rate of applied N reduced the levels of extractable K, Ca, and Mg and the soil pH. As the application of N increased, N removal in the harvested forage also increased, but the levels of K, Ca, Mg, and pH of the soil decreased.

The uptake of P was positively correlated ($P<0.01$) with removal of K and Mg in the harvested forage, and with the amount of extractable P in the soil. Highly significant negative correlations were obtained between P uptake and the levels of extractable Ca and Mg and soil pH. A highly significant positive relationship existed between K removal and K level in the soil. This was expected since the K content of the soil increased with K fertilization. However, approximately 21% of the variation in K removal could be accounted for by changes in the amount of extractable K in the soil. The removal of K in the harvested forage was negatively correlated ($P<0.01$) with the levels of extractable Ca and Mg in the soil and with soil pH.

Ca removal and Mg removal were positively correlated, with an r value of .92. The high correlation between Ca and Mg uptakes indicates a consistent ratio of the two nutrients in the oat-ryegrass forage. Ca removal was negatively related to extractable K, but positively associated with Mg level in the soil. There was no relationship between Ca removal and extractable Ca or soil pH. Since Ca was not applied to the experimental area after the initiation of the study, and the extractable Ca and

Table 18. Correlation coefficients among dry forage yield, pounds of plant nutrients removed in the harvested forage, and soil test results

1967

	Removal, lbs/a				Extractable elements, ppm				Soil
	N	P_2O_5	K_2O	Ca	P	K	Ca	Mg	pH
Yield	.81**	.80**	.65**	.61**	.42*	.14	-.52**	-.39*	-.43*
N_r		.51**	.32	.82**	.20	-.33	-.61**	-.66**	-.72**
P_2O_{5r}			.53**	.43*	.74**	.25	-.43*	-.15	-.21
K_2O_r				-.12	.13	.59**	-.28	-.08	-.05
Ca_r					.31	-.47*	-.43*	-.59**	-.68**
P_e						.19	-.13	.13	.04
K_e							.21	.39*	.48**
Ca_e								.73**	.77**
Mg_e									.92**

1968

	Removal, lbs/a					Extractable elements, ppm				Soil
	N	P_2O_5	K_2O	Ca	Mg	P	K	Ca	Mg	pH
Yield	.94**	.66**	.67**	.71**	.58**	.07	-.09	-.53**	-.68**	-.49**
N_r		.61**	.45*	.84**	.77**	.04	-.33	-.59**	-.72**	-.66**
P_2O_5r			.32	.57**	.53**	.66**	-.02	-.33	-.48**	-.39*
K_2Or				.07	-.12	-.05	.47*	-.41	-.51	-.10
Ca_r					.91**	.17	-.60**	-.32	-.48**	-.50**
Mg_r						.17	-.71**	-.40*	-.46*	-.61**
P_e							.07	.04	-.18	-.13
K_e								.19	.02	.37
Ca_e									.79**	.68**
Mg_e										.70**

(continued)

Table 18. (Continued)

1969

	Removal, lbs/a					Extractable elements, ppm				Soil
	N	P_2O_5	K_2O	Ca	Mg	P	K	Ca	Mg	pH
Yield	.93**	.73**	.58**	.77**	.71**	-.01	-.16	-.60**	-.67**	-.70**
N_r		.63**	.37	.85**	.84**	-.09	-.33	-.59**	-.68**	-.76**
P_2O_{5r}			.45*	.62**	.53**	.55**	.01	-.42*	-.51**	-.49**
K_2O_r				.04	-.08	-.04	.53**	-.38*	-.45*	-.32
Ca_r					.94**	.03	-.49**	-.44*	-.53**	-.63**
Mg_r						.04	-.62**	-.38*	-.42*	-.59**
P_e							-.09	.14	.07	.08
K_e								-.04	-.09	.11
Ca_e									.90**	.91**
Mg_e										.92**

1970

	Removal, lbs/a					Extractable elements, ppm				Soil
	N	P_2O_5	K_2O	Ca.	Mg.	P	K	Ca.	Mg.	pH
Yield	.92**	.70**	.76**	.23	.43*	.09	.09	-.67**	-.63	-.58**
N_r		.62**	.50**	.48**	.67**	.08	-.22	-.72**	-.67**	-.71**
P_2O_{5r}			.49**	.38*	.44*	.53**	.13	-.30	-.41*	-.33
K_2O_r				-.31	-.21	.04	.58**	-.49**	-.49**	-.31
Ca_r					.80**	.09	-.66**	-.23	-.26	-.45*
Mg_r						.20	-.66**	-.29	-.22	-.43*
P_e							.01	.10	-.07	.05
K_e								.05	-.08	.24
Ca_e									.89**	.84**
Mg_e										.87**

(continued)

Table 18. (Continued)

1971

	Removal, lbs/a					Extractable elements, ppm				Soil
	N	P_2O_5	K_2O	Ca	Mg	P	K	Ca	Mg	pH
Yield	.98**	.81**	.73**	.77**	.79**	-.04	-.30	-.73**	-.72**	-.70**
N_r		.75**	.62**	.84**	.86**	-.08	-.39*	-.80**	-.72**	-.77**
$P_2O_{5\,r}$			.66**	.54**	.57**	.46*	-.09	-.42*	-.57**	-.44*
K_2O_r				.15	.19	.01	.28	-.43*	-.68**	-.36
Ca_r					.97**	-.11	-.68**	-.70**	-.44*	-.72**
Mg_r						-.06	-.64**	-.73**	-.48**	-.78**
P_e							.32	.24	-.05	.13
K_e								.25	-.11	.29
Ca_e									.77**	.82**
Mg_e										.71**

5-Year Average

	Removal, lbs/a					Extractable elements, ppm				Soil
	N	P_2O_5	K_2O	Ca	Mg[1]	P	K	Ca	Mg	pH
Yield	.65**	.24**	.39**	.80**	.66**	-.09	-.20*	-.09	.30**	.17
N_r		.58**	.52**	.63**	.79**	.04	-.25**	-.53**	-.41**	-.39**
$P_2O_{5\,r}$			.53**	.13	.49**	.64**	.16	-.49**	-.53**	-.49**
K_2O_r				-.01	.06	.10	.46**	-.42**	-.40**	-.28**
Ca_r					.92**	-.11	-.50**	-.02	.25**	-.01
Mg_r						.10	-.51**	-.33**	-.25**	-.12
P_e							.16	-.09	-.24**	-.24**
K_e								-.02	-.21*	-.06
Ca_e									.74**	.57**
Mg_e										.66**

r Removal.
e Extractable.
1 Four-year average.

* Significant at P/.05 level of probability.
** Significant at P$\underline{/}$.01 level of probability.

soil pH declined during the course of the experiment, it appears that some correlation should have occurred between Ca removal and extractable Ca and soil pH. No explanation is offered for the lack of an association among these variables.

The uptake of Mg in the forage was negatively correlated ($P<.01$) with the levels of extractable K, Ca, and Mg in the soil. All the negative associations found between nutrient removal and the exchangeable cations in the soil were probably related to the inverse effects of applied N on total yield and concentration of the cations, K, Ca, and Mg, in the soil. The application of N resulted in increased yield of forage, and thus greater quantities of the cations were removed. The effect of added N was to reduce the amounts of K, Ca, and Mg in the soil, which resulted in the negative correlations between nutrient removal and cation concentration in the soil.

No significant relationship was found between extractable P and extractable K and Ca. The correlations of extractable P with extractable Mg and soil pH were negative and highly significant but of small magnitude. The significant negative correlation between extractable K and Mg was also of small magnitude, indicating little real association between the two variables.

The amount of extractable Ca in the soil was positively correlated ($P<.01$) with extractable Mg. Extractable Mg was positively correlated with soil pH.

SUMMARY AND CONCLUSIONS

1. *Nutrient Removal*

The removal of applied N, P_2O_5, and K_2O in the harvested forage of an oat-ryegrass mixture increased significantly with increased application of the respective nutrients. Removal of Ca and Mg increased as N applications increased, but decreased as K_2O applications increased. Generally, the rate of uptake of N, P_2O_5, K_2O, Ca, and Mg throughout the season was most rapid during November and from mid-February to mid-April. However, seasonal distribution of the rate of nutrient removal was not appreciably affected by rates of applied N, P_2O_5, or K_2O. Seasonal distribution of the rate of nutrient removal in the non-fertilized forage did not fluctuate as did that in the fertilized forage.

2. *Applied Nutrient Utilization*

The efficiency of utilization of applied N decreased from 73% to 59% as N rates increased from 200 to 400 pounds per acre. Nitrogen utilization increased slightly at the higher rates of applied N when P_2O_5 and K_2O increased from 100 to 200 pounds per acre. The utilization of

N increased twofold when N was applied in combination with P_2O_5 and K_2O as compared with N applied alone.

The utilization of applied P_2O_5 decreased from 21% to 12% when rates of applied P_2O_5 increased from 100 to 300 pounds per acre. The applied P_2O_5 was more efficiently utilized where the higher rates of N and K_2O were applied. That is, the utilization of P_2O_5 applied at the 100-pound rate increased approximately 8 percentage units where the N rate increased from 200 to 400 pounds per acre, and where the K_2O rate increased from 100 to 300 pounds per acre. The utilization of P_2O_5 increased sixfold when it was applied in combination with N and K_2O as compared with P_2O_5 applied alone.

The average utilization of applied K_2O was essentially the same at the 100- and 300-pound per acre rates, but was 10 percentage units less efficient than at the 200-pound rate. Application of 300 pounds of N increased the K_2O utilization by 21 percentage units over that of 200 pounds of applied N. The utilization of K_2O increased ninefold when it was applied in combination with N and P_2O_5 as compared with K_2O applied alone.

These data indicate the need for the application of N, P_2O_5, and K_2O in combination for the most efficient utilization of these applied plant nutrients by an oat-ryegrass mixture on a Lexington silt loam soil.

3. *Chemical Soil Analyses*

Extractable P in the soil increased significantly from 60 to 113 ppm as P_2O_5 rates increased from 100 to 300 pounds per acre annually. Phosphorus content did not accumulate significantly in the soil over the five-year period at the 100-pound rate of applied P_2O_5. At the termination of the study, extractable P was characterized as medium in availability in the soil that had received 100 pounds of P_2O_5 annually, and very high in soil that had received the two higher rates of P_2O_5. Extractable P was not significantly depleted in soil that received no applied fertilizer.

The extractable K content increased from 39 to 90 ppm where applied K_2O increased from 100 to 300 pounds per acre, as an average over the five-year period. However, at the highest rate of accumulation, the K level was characterized as very low in availability. Increasing the N rate from 200 to 400 pounds per acre significantly decreased the level of extractable K from 64 to 45 ppm.

Increased rates of applied N significantly decreased the levels of extractable Ca. Averaged over all years and all rates of applied P_2O_5 and K_2O, the decrease in extractable Ca was greater between applications of 200 and 300 pounds of N than between applications of 300 and 400 pounds of N.

Extractable Mg levels were significantly reduced as N applications were increased. Extractable Mg content was also significantly reduced generally each additional year after the initial year of the study, regardless of the rate of N applied.

The pH of the soil dropped significantly with each increase in N rate above 200 pounds per acre. The average decrease in pH due to N rates was approximately 0.3 unit.

4. *Correlations*

There was a highly significant positive association among forage yield and pounds of N, P_2O_5, K_2O, Ca, and Mg removed in the harvested forage. There was generally a high association in removal among all the plant nutrients measured.

The relationships between forage yield and the chemical values of extractable P, K, Ca, and Mg and soil pH were lower than expected. Generally, significant correlations occurred between yield and extractable Ca and Mg and soil pH. Yield was not significantly related to P and K contents in the soil.

5. *General*

These data indicate that nutrient removal by an oat-ryegrass mixture can be altered significantly by varying rates and ratios of applied N, P_2O_5, and K_2O. These data also suggest a need for additional calibration research that would better correlate chemical soil analyses with forage yield and nutrient removal. These data indicate that soil samples analyzed and interpreted on an annual basis provide guidelines on the fertility status and needs of a soil for forage crop production.

APPENDIX

Tables 19 through 31 are presented in the Appendix to document treatment effects on chemical analyses of the soil. Although treatments did result in certain chemical values being statistically significant, in many cases the differences were small.

Table 19. Effects of N and P_2O_5 applied annually to an oat-ryegrass mixture on extractable P

	N, lbs/a with 100 lbs of P_2O_5/a			
Year	200	300	400	Av
	P, ppm			
1967	64^{a1}	56^{a1}	60^{a1}	60^{12}
1968	55^{a1}	53^{a1}	56^{a1}	55^{1}
1969	57^{a1}	57^{a1}	57^{a1}	57^{1}
1970	67^{a1}	68^{a1}	70^{a1}	68^{2}
1971	60^{a1}	64^{a1}	58^{a1}	61^{12}
Av	60^{aI}	60^{aI}	60^{aI}	60^{I}

	N, lbs/a with 200 lbs of P_2O_5/a			
Year	200	300	400	Av
	P, ppm			
1967	73^{a1}	74^{a1}	73^{a1}	74^{1}
1968	82^{a12}	77^{a1}	83^{a1}	81^{12}
1969	86^{a12}	76^{a1}	80^{a1}	81^{12}
1970	109^{a3}	101^{a2}	101^{a2}	104^{3}
1971	94^{a23}	87^{a12}	83^{a1}	88^{2}
Av	89^{aII}	83^{aII}	84^{aII}	85^{II}

	N, lbs/a with 300 lbs of P_2O_5/a			
Year	200	300	400	Av
	P, ppm			
1967	87^{a1}	80^{a1}	89^{a1}	85^{1}
1968	116^{b2}	93^{a1}	100^{ab12}	103^{2}
1969	131^{b2}	114^{ab2}	104^{a12}	116^{3}
1970	151^{a3}	152^{a3}	139^{a3}	147^{4}
1971	127^{b2}	120^{ab2}	109^{a2}	119^{3}
Av	123^{bIII}	112^{aIII}	108^{aIII}	114^{III}

Means with same letter superscript within rows or same number superscript within columns do not differ significantly at $P \angle .05$.

Table 20. Effects of N and K_2O applied annually to an oat-ryegrass mixture on extractable P

	K_2O, lbs/a with 200 lbs of N/a			
Year	100	200	300	Av
	P, ppm			
1967	83^{a1}	70^{a1}	72^{a1}	75^{1}
1968	83^{a1}	79^{a12}	90^{a23}	84^{2}
1969	88^{ab12}	103^{b34}	82^{a12}	91^{23}
1970	102^{a2}	115^{a4}	110^{a4}	109^{4}
1971	87^{a12}	90^{ab23}	104^{b34}	94^{3}
Av	89^{aI}	91^{aII}	92^{aII}	91^{II}

	K_2O, lbs/a with 300 lbs of N/a			
Year	100	200	300	Av
	P, ppm			
1967	65^{a1}	65^{a1}	80^{a12}	70^{1}
1968	75^{a12}	72^{a12}	77^{a12}	74^{12}
1969	87^{a2}	86^{a23}	73^{a1}	82^{23}
1970	108^{a3}	103^{a4}	110^{a3}	107^{4}
1971	89^{a2}	89^{a34}	93^{a2}	90^{3}
Av	85^{aI}	83^{aI}	87^{aII}	85^{I}

	K_2O, lbs/a with 400 lbs of N/a			
Year	100	200	300	Av
	P, ppm			
1967	73^{ab1}	83^{b1}	66^{a1}	74^{1}
1968	80^{a1}	83^{a1}	75^{a1}	80^{12}
1969	80^{a1}	84^{a1}	78^{a1}	81^{12}
1970	112^{a2}	100^{a1}	98^{a2}	103^{3}
1971	86^{a1}	88^{a1}	76^{a1}	84^{2}
Av	86^{bI}	$88^{bI\ II}$	79^{aI}	84^{I}

Means with same letter superscript within rows or same number superscript within columns do not differ significantly at $P \angle .05$.

Table 21. Effects of N and P_2O_5 applied annually to an oat-ryegrass mixture on extractable K

	N, lbs/a with 100 lbs of P_2O_5/a			
Year	200	300	400	Av
	K, ppm			
1967	47^{b1}	42^{ab1}	38^{a1}	43^{1}
1968	62^{b2}	55^{ab2}	47^{a1}	55^{23}
1969	68^{b23}	44^{a1}	42^{a1}	51^{2}
1970	79^{c3}	60^{b2}	41^{a1}	60^{3}
1971	68^{b23}	49^{a12}	50^{a1}	56^{23}
Av	65^{cI}	50^{bI}	43^{aI}	53^{I}

	N, lbs/a with 200 lbs of P_2O_5/a			
Year	200	300	400	Av
	K, ppm			
1967	49^{b1}	46^{b1}	39^{a1}	44^{1}
1968	60^{b12}	51^{ab1}	47^{a12}	53^{2}
1969	68^{b2}	60^{ab23}	49^{a12}	59^{23}
1970	70^{b2}	65^{ab3}	53^{a2}	63^{3}
1971	70^{b2}	57^{ab123}	46^{a12}	58^{23}
Av	63^{cI}	56^{bII}	47^{aI}	55^{I}

	N, lbs/a with 300 lbs of P_2O_5/a			
Year	200	300	400	Av
	K, ppm			
1967	47^{a1}	45^{a1}	41^{a1}	44^{1}
1968	62^{b2}	51^{ab12}	47^{a1}	54^{23}
1969	58^{a12}	56^{a12}	43^{a1}	52^{2}
1970	69^{b2}	59^{ab2}	49^{a1}	59^{23}
1971	81^{b3}	56^{a12}	47^{a1}	61^{3}
Av	64^{cI}	$53^{bI\ II}$	45^{aI}	54^{I}

Means with same letter superscript within rows or same number superscript within columns do not differ significantly at $P \angle .05$.

Table 22. Effects of P_2O_5 and K_2O applied annually to an oat-ryegrass mixture on extractable K

	P_2O_5, lbs/a with 100 lbs of K_2O/a			
Year	100	200	300	Av
	---------------K, ppm---------------			
1967	38^{a1}	42^{a1}	40^{a1}	40^{1}
1968	40^{a1}	39^{a1}	45^{a1}	41^{1}
1969	31^{a1}	35^{a1}	35^{a1}	34^{1}
1970	34^{a1}	37^{a1}	36^{a1}	36^{1}
1971	37^{a1}	34^{a1}	35^{a1}	35^{1}
Av	36^{aI}	38^{aI}	38^{aI}	37^{I}

	P_2O_5, lbs/a with 200 lbs of K_2O/a			
Year	100	200	300	Av
	---------------K, ppm---------------			
1967	44^{a1}	41^{a1}	42^{a1}	42^{1}
1968	52^{a1}	51^{a1}	51^{a12}	51^{2}
1969	49^{a1}	55^{a1}	48^{a12}	51^{2}
1970	51^{a1}	51^{a1}	57^{a2}	53^{2}
1971	55^{a1}	57^{a1}	75^{b3}	62^{3}
Av	50^{aII}	51^{aII}	55^{aII}	52^{II}

	P_2O_5, lbs/a with 300 lbs of K_2O/a			
Year	100	200	300	Av
	---------------K, ppm---------------			
1967	46^{a1}	50^{a1}	50^{a1}	49^{1}
1968	72^{a2}	68^{a2}	65^{a2}	68^{2}
1969	75^{a2}	86^{a3}	74^{a23}	78^{3}
1970	96^{ab3}	100^{b4}	84^{a3}	94^{4}
1971	75^{a2}	83^{a3}	73^{a23}	77^{3}
Av	73^{abIII}	77^{bIII}	69^{aIII}	73^{III}

Means with same letter superscript within rows or same number superscript within columns do not differ significantly at $P<.05$.

Table 23. Effects of P_2O_5 and K_2O applied annually to an oat-ryegrass mixture on extractable Ca

	P_2O_5, lbs/a with 100 lbs of K_2O/a			
Year	100	200	300	Av
	---Ca, ppm---			
1967	615^{a2}	531^{a1}	564^{a1}	570^{23}
1968	552^{a12}	533^{a1}	561^{a1}	549^{23}
1969	525^{a12}	487^{a1}	527^{a1}	513^{12}
1970	482^{a1}	480^{a1}	499^{a1}	487^{1}
1971	487^{a1}	467^{a1}	483^{a1}	479^{1}
Av	532^{aII}	500^{aI}	527^{aII}	520^{II}

	P_2O_5, lbs/a with 200 lbs of K_2O/a			
Year	100	200	300	Av
	---Ca, ppm---			
1967	517^{a1}	488^{a1}	501^{a1}	502^{2}
1968	520^{a1}	501^{a1}	506^{a1}	509^{2}
1969	477^{a1}	437^{a1}	505^{a1}	473^{12}
1970	432^{a1}	428^{a1}	458^{a1}	440^{1}
1971	462^{a1}	453^{a1}	490^{a1}	468^{12}
Av	482^{aI}	461^{aI}	$492^{aI\ II}$	468^{I}

	P_2O_5, lbs/a with 300 lbs of K_2O/a			
Year	100	200	300	Av
	---Ca, ppm---			
1967	563^{a2}	519^{a12}	497^{a1}	527^{2}
1968	538^{a12}	542^{a2}	504^{a1}	528^{2}
1969	492^{a12}	472^{a12}	453^{a1}	473^{1}
1970	452^{a1}	433^{a1}	437^{a1}	441^{1}
1971	452^{a1}	463^{a12}	489^{a1}	468^{1}
Av	$500^{aI\ II}$	486^{aI}	476^{aI}	487^{I}

Means with same letter superscript within rows or same number superscript within columns do not differ significantly at $P \angle .05$.

Table 24. Effects of N and K_2O applied annually to an oat-ryegrass mixture on extractable Ca

	K_2O, lbs/a with 200 lbs of N/a			
Year	100	200	300	Av
	Ca, ppm			
1967	623^{a1}	593^{a1}	552^{a1}	589^{2}
1968	622^{a1}	539^{a1}	547^{a1}	570^{12}
1969	585^{b1}	534^{ab1}	486^{a1}	535^{12}
1970	567^{a1}	505^{a1}	488^{a1}	520^{1}
1971	550^{a1}	520^{a1}	525^{a1}	532^{12}
Av	590^{bIII}	538^{aII}	520^{aII}	549^{III}

	K_2O, lbs/a with 300 lbs of N/a			
Year	100	200	300	Av
	Ca, ppm			
1967	594^{b2}	439^{a1}	520^{ab1}	518^{23}
1968	536^{a12}	487^{a1}	546^{a1}	523^{3}
1969	502^{a12}	447^{a1}	485^{a1}	478^{123}
1970	472^{a1}	433^{a1}	453^{a1}	453^{1}
1971	480^{a1}	452^{a1}	460^{a1}	464^{12}
Av	517^{bII}	451^{aI}	493^{bII}	487^{II}

	K_2O, lbs/a with 400 lbs of N/a			
Year	100	200	300	Av
	Ca, ppm			
1967	492^{a1}	474^{a12}	508^{a2}	492^{2}
1968	488^{a1}	501^{a2}	491^{a2}	493^{2}
1969	452^{a1}	437^{a12}	447^{a12}	446^{12}
1970	422^{a1}	381^{a1}	381^{a1}	394^{1}
1971	407^{a1}	433^{a12}	419^{a12}	420^{1}
Av	452^{a1}	445^{a1}	449^{a1}	449^{1}

Means with same letter superscript within rows or same number superscript within columns do not differ significantly at $P \angle .05$.

Table 25. Effects of P_2O_5 and K_2O applied annually to an oat-ryegrass mixture on extractable Mg

	P_2O_5, lbs/a with 100 lbs of K_2O/a			
Year	100	200	300	Av
	Mg, ppm			
1967	197^{a4}	177^{a3}	193^{a4}	189^{4}
1968	172^{a3}	163^{a23}	167^{a3}	167^{3}
1969	156^{a23}	148^{a2}	153^{a23}	152^{23}
1970	148^{a2}	144^{a2}	143^{a12}	145^{2}
1971	129^{a1}	117^{a1}	128^{a1}	125^{1}
Av	160^{bII}	150^{aI}	157^{abII}	156^{II}

	P_2O_5, lbs/a with 200 lbs of K_2O/a			
Year	100	200	300	Av
	Mg, ppm			
1967	175^{a4}	179^{a4}	190^{a4}	181^{4}
1968	159^{a34}	157^{a3}	162^{a3}	159^{3}
1969	147^{a23}	140^{a23}	147^{a23}	145^{23}
1970	134^{a2}	133^{a2}	140^{a2}	136^{2}
1971	112^{a1}	110^{a1}	114^{a1}	112^{1}
Av	145^{aI}	144^{aI}	151^{aII}	147^{I}

	P_2O_5, lbs/a with 300 lbs of K_2O/a			
Year	100	200	300	Av
	Mg, ppm			
1967	188^{a4}	190^{a4}	178^{a3}	185^{4}
1968	158^{a3}	160^{a3}	147^{a2}	155^{3}
1969	144^{a23}	139^{a2}	136^{a2}	140^{2}
1970	135^{a2}	128^{a2}	127^{a2}	130^{2}
1971	111^{a1}	109^{a1}	108^{a1}	109^{1}
Av	147^{aI}	145^{aI}	139^{aI}	144^{I}

Means with same letter superscript within rows or same number superscript within columns do not differ significantly at $P \angle .05$.

Table 26. Effects of N and K_2O applied annually to an oat-ryegrass mixture on extractable Mg

	K_2O, lbs/a with 200 lbs of N/a			
Year	100	200	300	Av
	Mg, ppm			
1967	221^{a3}	196^{a4}	195^{a3}	204^{4}
1968	194^{b2}	171^{a3}	157^{a2}	174^{3}
1969	178^{c2}	159^{b23}	141^{a2}	160^{2}
1970	177^{b2}	150^{a2}	138^{a2}	155^{2}
1971	153^{b1}	125^{a1}	114^{a1}	131^{1}
Av	185^{cIII}	160^{bIII}	149^{aII}	165^{III}

	K_2O, lbs/a with 300 lbs of N/a			
Year	100	200	300	Av
	Mg, ppm			
1967	185^{a4}	180^{a4}	192^{a4}	186^{4}
1968	160^{a3}	161^{a3}	161^{a3}	161^{3}
1969	147^{a23}	139^{a2}	147^{a23}	144^{2}
1970	137^{a2}	138^{a2}	134^{a2}	136^{2}
1971	115^{a1}	110^{a1}	112^{a1}	112^{1}
Av	149^{aII}	146^{aII}	149^{aII}	148^{II}

	K_2O, lbs/a with 400 lbs of N/a			
Year	100	200	300	Av
	Mg, ppm			
1967	162^{a4}	168^{a4}	169^{a4}	166^{5}
1968	147^{a34}	146^{a3}	147^{a3}	147^{4}
1969	131^{a23}	135^{a23}	131^{a23}	133^{3}
1970	121^{a1}	119^{a12}	118^{a12}	119^{2}
1971	106^{a1}	101^{a1}	102^{a1}	103^{1}
Av	133^{aI}	134^{aI}	133^{aI}	134^{I}

Means with same letter superscript within rows or same number superscript within columns do not differ significantly at $P \angle .05$.

Table 27. Effects of P_2O_5 and K_2O applied annually to an oat-ryegrass mixture on soil reaction (pH)

	P_2O_5, lbs/a with 100 lbs of K_2O/a			
Year	100	200	300	Av
	pH			
1967	5.63^{a2}	5.51^{a2}	5.62^{a3}	5.59^{3}
1968	6.17^{a3}	6.14^{a3}	6.18^{a4}	6.16^{4}
1969	5.63^{a2}	5.52^{a2}	5.58^{a3}	5.58^{3}
1970	5.08^{a1}	5.02^{a1}	5.07^{a2}	5.06^{2}
1971	4.93^{a1}	4.91^{a1}	4.84^{a1}	4.89^{1}
Av	5.49^{aII}	5.42^{aI}	5.46^{aI}	5.46^{II}

	P_2O_5, lbs/a with 200 lbs of K_2O/a			
Year	100	200	300	Av
	pH			
1967	5.52^{a3}	5.49^{a2}	5.56^{a2}	5.52^{3}
1968	6.20^{a4}	6.14^{a3}	6.18^{a3}	6.17^{4}
1969	5.52^{a3}	5.45^{a2}	5.57^{a2}	5.51^{3}
1970	5.01^{a2}	4.97^{a1}	5.06^{a1}	5.01^{2}
1971	4.75^{a1}	4.87^{a1}	4.94^{a1}	4.85^{1}
Av	5.40^{aI}	5.38^{aI}	5.46^{aI}	5.41^{I}

	P_2O_5, lbs/a with 300 lbs of K_2O/a			
Year	100	200	300	Av
	pH			
1967	5.60^{a2}	5.59^{a2}	5.55^{a2}	5.58^{3}
1968	6.26^{a3}	6.22^{a3}	6.14^{a3}	6.21^{4}
1969	5.57^{a2}	5.51^{a2}	5.51^{a2}	5.53^{3}
1970	5.03^{a1}	5.03^{a1}	5.02^{a1}	5.03^{2}
1971	4.88^{a1}	4.93^{a1}	4.92^{a1}	4.91^{1}
Av	$5.47^{aI\ II}$	5.46^{aI}	5.43^{aI}	$5.45^{I\ II}$

Means with same letter superscript within rows or same number superscript within columns do not differ significantly at $P \angle .05$.

Table 28. Effects of N and K_2O applied annually to an oat-ryegrass mixture on soil reaction (pH)

	K_2O, lbs/a with 200 lbs of N/a			
Year	100	200	300	Av
	pH			
1967	5.74^{a2}	5.62^{a2}	5.67^{a2}	5.67^{3}
1968	6.30^{a3}	6.24^{a3}	6.23^{a3}	6.26^{4}
1969	5.82^{b2}	5.64^{a2}	5.59^{a2}	5.69^{3}
1970	5.25^{a1}	5.16^{a1}	5.16^{a1}	5.19^{2}
1971	5.07^{a1}	5.02^{a1}	5.05^{a1}	5.04^{1}
Av	5.64^{bIII}	5.53^{aIII}	5.54^{aII}	5.57^{III}

	K_2O, lbs/a with 300 lbs of N/a			
Year	100	200	300	Av
	pH			
1967	5.64^{a2}	5.52^{a2}	5.60^{a2}	5.59^{3}
1968	6.21^{a3}	6.18^{a3}	6.28^{a3}	6.22^{4}
1969	5.56^{a2}	5.48^{a2}	5.62^{a2}	5.56^{3}
1970	5.06^{a1}	5.01^{a1}	5.07^{a1}	5.05^{2}
1971	4.92^{a1}	4.85^{a1}	4.93^{a1}	4.90^{1}
Av	5.48^{abII}	5.41^{aII}	5.50^{bII}	5.46^{II}

	K_2O, lbs/a with 400 lbs of N/a			
Year	100	200	300	Av
	pH			
1967	5.37^{a2}	5.43^{a2}	5.47^{a2}	5.43^{3}
1968	5.98^{a3}	6.10^{a3}	6.10^{a3}	6.06^{4}
1969	5.36^{a2}	5.41^{a2}	5.37^{a2}	5.38^{3}
1970	4.86^{a1}	4.87^{a1}	4.87^{a1}	4.87^{2}
1971	4.70^{a1}	4.69^{a1}	4.76^{a1}	4.72^{1}
Av	5.25^{aI}	5.30^{aI}	5.31^{aI}	5.29^{I}

Means with same letter superscript within rows or same number superscript within columns do not differ significantly at $P\angle.05$.

Table 29. Effects of N and P_2O_5 applied annually to an oat-ryegrass mixture on percent soil organic matter (OM)

	N, lbs/a with 100 lbs of P_2O_5/a			
Year	200	300	400	Av
	% OM			
1969	1.70^{a2}	1.69^{a2}	1.80^{a2}	1.73^{2}
1970	1.40^{a1}	1.38^{a1}	1.50^{a1}	1.43^{1}
1971	1.48^{a1}	1.50^{a1}	1.49^{a1}	1.49^{1}
Av	1.49^{aI}	1.49^{aII}	1.55^{aII}	1.51^{II}

	N, lbs/a with 200 lbs of P_2O_5/a			
Year	200	300	400	Av
	% OM			
1969	1.69^{a2}	1.64^{a2}	1.78^{a2}	1.71^{2}
1970	1.44^{a1}	1.37^{a1}	1.43^{a1}	1.42^{1}
1971	1.50^{a1}	1.44^{a1}	1.50^{a1}	1.48^{1}
Av	1.52^{aI}	1.46^{aII}	1.53^{aII}	1.50^{II}

	N, lbs/a with 300 lbs of P_2O_5/a			
Year	200	300	400	Av
	% OM			
1969	1.58^{a2}	1.50^{a2}	1.62^{a2}	1.57^{2}
1970	1.42^{a1}	1.30^{a1}	1.38^{a1}	1.37^{1}
1971	1.50^{a12}	1.38^{a12}	1.39^{a1}	1.43^{1}
Av	1.49^{bI}	1.38^{aI}	1.43^{abI}	1.43^{I}

Means with same letter superscript within rows or same number superscript within columns do not differ significantly at $P \angle .05$.

Table 30. Effects of P_2O_5 and K_2O applied annually to an oat-ryegrass mixture on percent soil organic matter (OM)

	P_2O_5, lbs/a with 100 lbs of K_2O/a			
Year	100	200	300	Av
	% OM			
1969	1.68^{a2}	1.68^{a2}	1.51^{a1}	1.63^{2}
1970	1.42^{a1}	1.43^{a1}	1.39^{a1}	1.41^{1}
1971	1.44^{a1}	1.47^{a1}	1.38^{a1}	1.43^{1}
Av	1.48^{abI}	1.50^{bI}	1.41^{aI}	1.46^{I}

	P_2O_5, lbs/a with 200 lbs of K_2O/a			
Year	100	200	300	Av
	% OM			
1969	1.82^{a2}	1.72^{a2}	1.66^{a2}	1.73^{3}
1970	1.44^{a1}	1.37^{a1}	1.34^{a1}	1.39^{1}
1971	1.54^{b1}	1.45^{ab1}	1.41^{a1}	1.47^{2}
Av	1.56^{bII}	1.48^{abI}	1.43^{aI}	1.49^{I}

	P_2O_5, lbs/a with 300 lbs of K_2O/a			
Year	100	200	300	Av
	% OM			
1969	1.68^{a2}	1.71^{a2}	1.55^{a2}	1.65^{3}
1970	1.42^{a1}	1.45^{a1}	1.37^{a1}	1.41^{1}
1971	1.48^{a1}	1.52^{a1}	1.49^{a12}	1.50^{2}
Av	$1.50^{abI\ II}$	1.53^{bI}	1.45^{aI}	1.49^{I}

Means with same letter superscript within rows or same number superscript within columns do not differ significantly at $P \angle .05$.

Table 31. Effects of N and K_2O applied annually to an oat-ryegrass mixture on percent soil organic matter (OM)

	K_2O, lbs/a with 200 lbs of N/a			
Year	100	200	300	Av
	------------------ % OM	------------------		
1969	1.63^{a2}	1.75^{a2}	1.60^{a1}	1.66^{2}
1970	1.37^{a1}	1.44^{a1}	1.46^{a1}	1.42^{1}
1971	1.42^{a1}	1.47^{ab1}	1.58^{b1}	1.49^{1}
Av	1.44^{aI}	1.52^{bII}	1.53^{bII}	1.50^{II}

	K_2O, lbs/a with 300 lbs of N/a			
Year	100	200	300	Av
	------------------ % OM	------------------		
1969	1.65^{a2}	1.66^{a3}	1.52^{a2}	1.61^{3}
1970	1.40^{a1}	1.30^{a1}	1.35^{a1}	1.35^{1}
1971	1.42^{a1}	1.46^{a2}	1.45^{a12}	1.45^{2}
Av	1.46^{aI}	1.44^{aI}	1.43^{aI}	1.44^{I}

	K_2O, lbs/a with 400 lbs of N/a			
Year	100	200	300	Av
	------------------ % OM	------------------		
1969	1.59^{a2}	1.79^{b2}	1.82^{b2}	1.74^{2}
1970	1.47^{a12}	1.41^{a1}	1.43^{a1}	1.44^{1}
1971	1.44^{a1}	1.48^{a1}	1.46^{a1}	1.46^{1}
Av	1.48^{aI}	$1.51^{aI\ II}$	1.52^{aII}	1.51^{II}

Means with same letter superscript within rows or same number superscript within columns do not differ significantly at $P\angle.05$.

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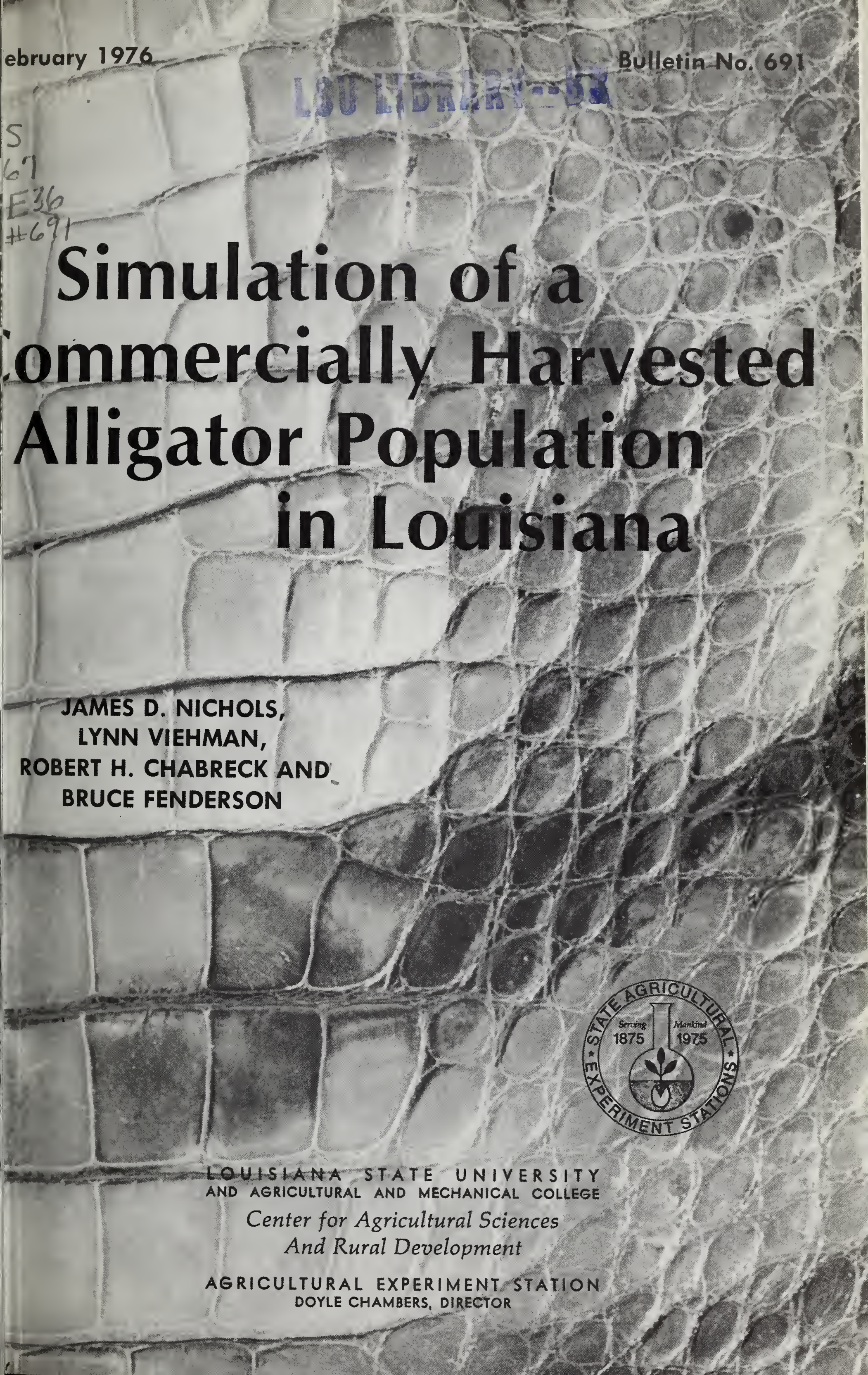

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Simulation of a ommercially Harvested Alligator Population in Louisiana

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ABSTRACT

A model was constructed to simulate the dynamics of a commercially harvested alligator (*Alligator mississippiensis* Daudin) population inhabiting the privately owned coastal marshland of Cameron and Vermilion parishes, Louisiana. In the model, nesting effort, nest flooding, desiccation mortality, and predation on alligator eggs and young were all determined as functions of monthly water depth averages. Cannibalism was considered to be the major density dependent factor operating on the population and was determined as a function of total population density and marsh water depth. The model contained a freeze mortality which was based on minimum winter temperatures. In addition, the model included a harvest option which resulted in alligator hunting mortality.

Comparison of simulation results with 1970-1973 nest count results demonstrated reasonably close agreement between simulated and observed data. Simulations of a June drought, a severe summer drought, and an August hurricane produced drastic population declines, although rapid recoveries were made in subsequent years. Environmentally stochastic simulations produced extremely irregular population response curves and resultant age structures.

Simulations were utilized to examine population response to various differential harvest rates in which age and sex-specific proportions of animals taken were similar to those observed in the 1972 and 1973 Louisiana harvest seasons. These simulations demonstrated that under existing habitat conditions a base population of 100,000 animals should be maintained for at least 20 years when subjected to an annual differential harvest rate slightly greater than 5 percent. Simulations were conducted using proportional harvest rates in which animals of various sizes were taken in proportion to their relative abundance in the population. Comparison of proportional and differential harvest strategies indicated that proportional hunting can result in increased yields of alligator hide and resultant income. Simulations with egg collection management programs produced greater population increases than similar simulations with no management.

Simulation of a Commercially Harvested Alligator Population in Louisiana

James D. Nichols[1], Lynn Viehman[2],
Robert H. Chabreck[3] and Bruce Fenderson[4]

INTRODUCTION

The American alligator is native to the southeastern portion of the United States and occurs in Louisiana, Florida, Georgia, South Carolina, Texas, Arkansas, Mississippi, Alabama, and North Carolina. Reports of early settlers and explorers in the southeastern part of the country emphasized the abundance of alligators, and in the early 19th century the reptile was apparently present in tremendous numbers (Chabreck 1967a).

Commercial harvesting of alligators began in the mid-19th century (Smith 1893), and peak harvests were realized in the late 1800's (McIlhenny 1935). Stevenson (1904) estimated that the alligator populations of Florida and Louisiana were reduced by 80 percent between 1880 and 1904. Heavy harvests continued, and by 1960 the alligator had been practically eliminated from most of its original range (Chabreck 1967a).

Despite a continuous decline in numbers since 1950, no significant effort was made to protect the alligator until the 1960's. During the 1960's, protective legislation was enacted by all states within the animal's range, and in 1966 the alligator was placed on the federal list of rare and endangered species. Then, in 1970, the United States Congress effected the Endangered Species Conservation Act and the amendment to the 1906 Lacey Act which prohibited interstate shipment of illegally taken alligators (Palmisano 1972). The combined effect of this federal action and the various state laws was sufficient to largely curtail illegal killing of alligators (Chabreck 1971a).

Alligator numbers in the southeastern United States have increased in recent years (Powell 1971), and this increase has been reported by workers in South Carolina (Bara 1971), Florida (Schemnitz 1972), and Louisiana (Palmisano 1972; Joanen and McNease 1972a, 1972b; Palmisano *et al.* 1973). The dramatic recovery of the American alligator has been noted by the IUCN Crocodile Specialists Group, which transferred the alligator from the "critically endangered" category to the "recovered" category in 1971 (Bustard 1971) and reaffirmed this assessment in 1973 (Crocodile Specialists Group 1973).

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In 1958, the Louisiana Wildlife and Fisheries Commission initiated an intensive alligator research program, the results of which have been summarized by Chabreck (1971a), Joanen and McNease (1973a), and Palmisano *et al.* (1973). The commission also effected various management procedures which included strict harvest control, restocking, and increased law enforcement efforts against poaching. These management efforts resulted in dramatic increases in the alligator population, and, by the late 1960's, high alligator densities existed in the coastal marshes of southwestern Louisiana. In 1970, the Louisiana state legislature established the framework for an open alligator season, and in 1972 and 1973 experimental harvests were conducted in the marshland of Cameron and Vermilion parishes. Preliminary results indicate that the 1972 harvest had no detrimental effect on the Cameron Parish alligator population (Palmisano *et al.* 1973).

Experimental harvest manipulations involving wild populations are potentially more dangerous to alligators than to most other commercially important wildlife species. This potential danger results from the high vulnerability of alligators to hunting, the long period required by alligators to reach sexual maturity, and the drastic effects of such natural phenomena as drought, severe freezes, and hurricanes on alligator populations.

The present study involves the use of computer simulation as a means of examining consequences of various alligator management strategies. The first objective of this study was to assemble all available information on the natural history and population dynamics of alligators and to use this information to construct a simulation model. The second major objective involved using the simulation model to examine the consequences of various alligator management strategies. The study's third objective was to examine possible long-term effects of different environmental changes on alligator populations. It was hoped that information provided by the study would not only be valuable in the management of the American alligator but would also serve as a basis for planning management strategies for other crocodilians throughout the world.

DESCRIPTION OF STUDY AREA

The model was constructed to simulate the alligator population inhabiting the privately owned marshland of Cameron and Vermilion parishes, Louisiana. This area comprises 1,144,600 acres of marsh (Joanen and McNease 1973b), and includes the land on which both Louisiana alligator harvests were conducted. The 1972 Louisiana alligator harvest was restricted to 278,168 acres of Cameron Parish marshland (Joanen *et al.* 1972, Palmisano *et al.* 1973), and the 1973 harvest was conducted on 541,361 acres in Cameron and Vermilion parishes (Joanen *et al.* 1973).

The Louisiana coastal region has been divided into three physiographic zones: the chenier plain, the sub-delta, and the active delta (O'Neil 1949). The study area was located in the chenier plain marsh zone of southwestern Louisiana, which contained the largest alligator population of the three zones. The chenier plain marsh zone borders the Gulf of Mexico, extends inland approximately 32 km (20 miles), and consists of coastal marshland interlaced with a network of bayous, canals, and lakes. The surface is relatively flat, and elevations average only about 30 cm (1 foot) above mean sea level (MSL); consequently, drainage in the area is quite slow. The only relief features are spoil deposits along canals and stranded beach ridges, locally called cheniers.

The Louisiana coastal marshes have been subdivided into four primary vegetative types: fresh, intermediate, brackish, and saline (Penfound and Hathaway 1938, Chabreck 1972). The study area included fresh, intermediate, and brackish marsh types, and recent descriptions of these types have been provided by Chabreck (1972). The fresh marsh was preferred by nesting female alligators to the other marsh types (Joanen and McNease 1972a).

Water depth in relation to the marsh elevation appeared to be an environmental parameter of extreme importance to alligators, and 9 years of water level data were obtained for the months April through October from stations within the study area (Table 1). Extreme fluctuations in water levels are associated with periods of prolonged drought with levels declining to as much as 61 cm (2 feet) below the marsh surface (Nichols 1959) or hurricanes with water inundating the marsh to a depth of 91 to 274 cm (3 to 9 feet). In the construction of various water level functions in the model, 15 cm (.5 foot) was generally considered to be the mean annual marsh water depth value (Chabreck 1960).

Data on water levels and alligator sizes in the United States are often expressed in linear foot measurements; consequently, the measure-

Table 1.—Marsh water depths in the study area[a]

Year	April	May	June	July	August	September	October
	— — —	— — —	— — —	cm (feet)	— — —	— — —	— — —
1965	12 (.4)	21 (.7)	18 (.6)	0 (.0)	6 (.2)	18 (.6)	24 (.8)
1966	12 (.4)	49 (1.6)	27 (.9)	24 (.8)	34 (1.1)	55 (1.8)	58 (1.9)
1967	21 (.7)	46 (1.5)	27 (.9)	15 (.5)	24 (.8)	49 (1.6)	27 (.9)
1968	24 (.8)	18 (.6)	12 (.4)	21 (.7)	27 (.9)	27 (.9)	21 (.7)
1969	18 (.6)	46 (1.5)	27 (.9)	3 (.1)	15 (.5)	24 (.8)	18 (.6)
1970	30 (1.0)	27 (.9)	37 (1.2)	24 (.8)	21 (.7)	34 (1.1)	40 (1.3)
1971	18 (.6)	3 (.1)	12 (.4)	0 (.0)	37 (1.2)	24 (.8)	43 (1.4)
1972	9 (.3)	24 (.8)	18 (.6)	9 (.3)	21 (.7)	15 (.5)	40 (1.3)
1973	18 (.6)	24 (.8)	27 (.9)	24 (.8)	37 (1.2)	24 (.8)	40 (1.3)
Mean	18 (.6)	27 (.9)	24 (.8)	12 (.4)	24 (.8)	30 (1.0)	34 (1.1)
St. Dev.	5.2 (.17)	13.4 (.44)	8.5 (.28)	8.8 (.29)	8.5 (.28)	11.9 (.39)	11.0 (.36)

[a] Source: Chabreck and Joanen (1966, 1967); Joanen *et al.* (1968, 1969, 1970, 1971, 1972, 1973, 1974).

ments presented in this report are expressed in the same manner to facilitate the interpretation of data. A metric conversion is also presented to comply with international standards.

ALLIGATOR POPULATION BIOLOGY

Size-Age Relationship

In most of the alligator literature, animals are categorized on the basis of total body length and are separated into one-foot size classes. The present study required age-specific rather than size-specific data, however, and information on alligator growth rates was necessary for such data conversions.

Alligator growth rate data have been presented by Reese (1915), Neill (1971), Chabreck (1965), Hines *et al.* (1968), and McIlhenny (1934), and the latter three reports seem to provide the best information for wild alligators. Chabreck (1965) presented average sizes of 1- and 2-year-old alligators in Louisiana. Hines *et al.* (1968) found a growth rate of 2.95 cm (1.16 inches) per month for immature alligators in the Florida Everglades. The Everglades growth data are not applicable to Louisiana alligators, however, because the Louisiana animals enter a semidormant stage during cold weather (McIlhenny 1935, Chabreck 1965) while Everglades animals do not become semidormant (Thompson and Gidden 1972). This difference in winter activity between Everglades and Louisiana alligators probably results in a higher growth rate for Everglades animals.

McIlhenny (1934) toe-marked and released 38 alligator hatchlings on Avery Island, Louisiana, and followed their growth for 11 years. Visual fit curves were derived from McIlhenny's data and these curves were projected beyond the last data points through 21 years (Figure 1). Perhaps it should be noted that these curves are not actually continuous throughout each year as the graph might indicate. Instead, alligator growth slows during the winter months and increases during the spring, summer, and fall. The curves were used to establish a general size-age relationship table which applies to alligators in the late summer of the specified years (Table 2). Table 2 was used in all conversions of size-specific to age-specific data. It should be emphasized that although McIlhenny's (1934) data are considered adequate for the model, additional research on alligator growth rates is certainly needed.

Food intake and temperature are variables which can affect alligator growth rate (Coulson *et al.* 1973), but no accurate data regarding these relationships are available for wild populations. McIlhenny's (1934) data were obtained in the coastal marshland of southwestern Louisiana, and it was assumed that the general temperature regime and the types of alligator prey species available were much the same as those existing on the study area. Regarding food availability, alligators utilize a wide variety of food sources, and it is difficult to imagine that they would be subjected to food shortages as frequently as other more specialized predator species. Chabreck (1971b) found that alligators exposed to saline conditions consumed less food than animals inhabiting fresh water areas. The study area for the simulated population, however, included virtually no saline areas, and this variable was thus ignored.

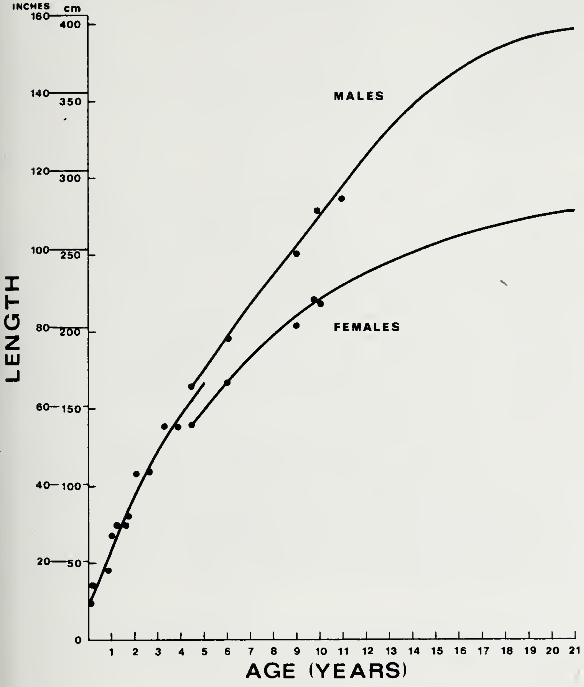

Figure 1.—Relationship between total length and age in alligators. Years begin September 1 and end August 31.

Table 2.—Alligator size-age relationship[a]

Age (years)	Body length[b] Males	Females	Age (years)	Body length[b] Males	Females
	— — — Meters (feet) — — —			— — — Meters (feet) — — — —	
1	.3- .6 (1-2)	.3- .6 (1-2)	12	2.7-3.0 (9-10)	2.1-2.4 (7-8)
2	.6- .9 (2-3)	.6- .9 (2-3)	13	3.0-3.4 (10-11)	2.1-2.4 (7-8)
3	.9-1.2 (3-4)	.9-1.2 (3-4)	14	3.0-3.4 (10-11)	2.1-2.4 (7-8)
4	1.2-1.5 (4-5)	1.2-1.5 (4-5)	15	3.4-3.7 (11-12)	2.4-2.7 (8-9)
5	1.5-1.8 (5-6)	1.2-1.5 (4-5)	16	3.4-3.7 (11-12)	2.4-2.7 (8-9)
6	1.5-1.8 (5-6)	1.5-1.8 (5-6)	17	3.7-4.0 (12-13)	2.4-2.7 (8-9)
7	1.8-2.1 (6-7)	1.5-1.8 (5-6)	18	3.7-4.0 (12-13)	2.4-2.7 (8-9)
8	2.1-2.4 (7-8)	1.5-1.8 (5-6)	19	3.7-4.0 (12-13)	2.4-2.7 (8-9)
9	2.4-2.7 (8-9)	1.8-2.1 (6-7)	20	3.7-4.0 (12-13)	2.4-2.7 (8-9)
10	2.4-2.7 (8-9)	1.8-2.1 (6-7)	21	3.7-4.0 (12-13)	2.4-2.7 (8-9)
11	2.7-3.0 (9-10)	1.8-2.1 (6-7)			

[a] Basically derived from McIlhenny (1934).

[b] Sizes generally apply to alligators at the beginning (September) of the designated year class.

Reproductive Biology

Alligator Courtship and Nesting—General Information

Alligator courtship and breeding were found to occur between May 18 and May 31 in a recent study in southwestern Louisiana (Joanen and McNease 1970a). Courtship activity during this time is apparently restricted to open water areas including bayous and canals, and marsh lakes and ponds greater than one acre in size (Joanen and McNease, 1970a). After courtship the adult females travel to dens in the interior marsh to construct nests and lay eggs. Details of alligator nest construction have been provided by Reese (1907), Kellogg (1929), Arthur (1931), McIlhenny (1934), Bellairs (1969), Joanen (1969), and Neill (1971).

In a 5-year study in southwestern Louisiana, Joanen (1969) found that the peak alligator nesting period varied between June 15 and June 28. Joanen correlated these peak nesting periods with average March, April, and May temperatures, but because he found only a 13-day difference between dates of peak nesting activity, the temperature-nesting period relationship was ignored in the model. Instead, nesting was assumed to occur at the end of June in each year.

Joanen (1969) reported that the number of eggs per nest ranged from 2 to 58 during his 5-year study. The average number of eggs per nest was 38.9, and this figure was incorporated in the model as a constant. The incubation period for alligator eggs is approximately 63 to 65 days (Chabreck 1967b, Joanen 1969). In the model, hatching thus occurred at the end of August.

Age of Sexual Maturity

Virtually all authorities agree that the female alligator reaches maturity at 1.8 meters (6 feet). In a sample of female alligators examined internally on Sabine National Wildlife Refuge in Louisiana, Giles and Childs (1949) found only one breeding female under 1.8 meters (6 feet) in length, and even this animal was believed to have approached this size. In his Rockefeller Refuge study, Joanen (1969) found that sizes of nesting females varied between 1.8 and 2.6 meters (6 and 8.5 feet). Kleibert (pers. comm.) has indicated that females generally begin nesting at age 9, and this corresponds to the beginning of the year at which female alligators move to the 1.8 to 2.1 meter (6 to 7 feet) size class (Table 2). In the model, female alligators were assumed to become sexually mature at age 9 and to continue breeding throughout the remainder of their lives.

All 1.8-4.0 meter (6-13 feet) male alligators examined by Joanen and McNease (1973a) were found to be physiologically capable of reproduction. Because of the usual surplus of males in adult alligator populations (Chabreck 1966) and because of the ability of individual males to breed with more than one female per season (Chabreck 1965), the number of adult males was considered to be unimportant in the computation of nesting females.

Nesting Effort

Chabreck (1966) cited data from Sabine Refuge kill survey records indicating that 68.1 percent of a sample of 69 adult females nested during one year. More recent work in southwestern Louisiana has indicated that 67 percent of the adult female segment of an alligator population is capable of reproducing during any given year (Joanen and McNease 1973a).

In 1971, alligator nest counts in southwestern Louisiana indicated that nesting had decreased by 39.5 percent from the previous year (Joanen and McNease 1972c). Joanen and McNease felt that the decreased number of nests was due to dry nesting conditions rather than to a decrease in the mature female segment of the population. These workers further stated that "nesting success may be proportional to the amount of surface water accrued during the spring on until actual egg deposition" (Joanen and McNease 1972c). This 1971 nesting decline has also been attributed to dry nesting conditions in later reports (Joanen and McNease 1973b, Palmisano *et al.* 1973), and Schemnitz (1972) has cited low water levels as the reason for a 1971 decline in alligator nesting in the Florida Everglades. Joanen and McNease (1970a, 1972a) stressed the need of female alligators for open water during courtship, and it is possible that this is part of the mechanism explaining reduced nesting effort during drought.

The nesting effort-water depth relationship appears to be extremely important to alligator population growth, and the relationship was thus included in the model. Using 1970 nest count data as a base, Joanen and McNease (1972c) reported percent changes in numbers of nests counted in 1971 for the three major Louisiana marsh zones, the chenier plain, −39.5 percent; the sub-delta, −6.0 percent; and the active delta, −22.1 percent. The chenier plain and sub-delta zones had much higher alligator populations than did the active delta, and nesting changes in these two zones were thus used to determine the nesting effort-water depth relationship.

Joanen and McNease (1972c) compared average January to June rainfall with alligator nesting success and noted the importance of the total surface water available during the spring. May and June marsh water depths are apparently important in regard to nesting effort, and this relationship was used in the model.

Chenier plain May-June water depth averages for the years 1970-1973 (Table 1) were plotted against total January to June rainfall (Figure 2). This relationship was assumed to be linear, and a visual fit line was drawn. Points corresponding to sub-delta rainfall figures were then marked along this line, and the average May-June water depth values were obtained from these points. This plot requires the assumption that rainfall and marsh water depth are similarly related in the chenier plain and sub-delta marsh zones. This assumption has not been tested, but drainage patterns in the two zones are similar, and the relationships should be basically the same.

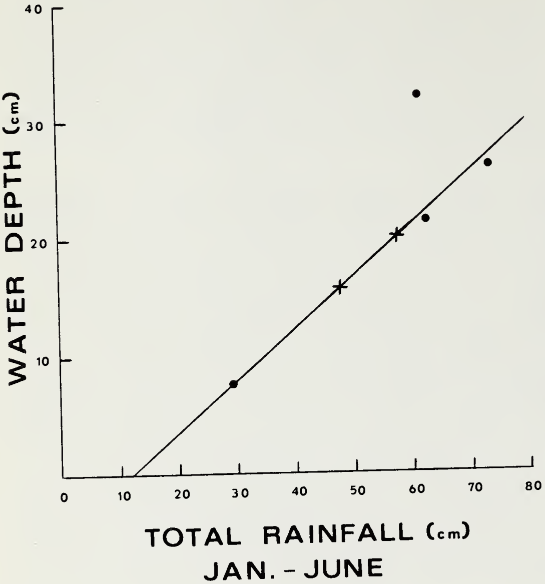

Figure 2.—Relationship between May-June marsh water depth averages and total January to June rainfall. Data points used in the construction of this relationship correspond to chenier plain water depths and rainfall levels, 1970-1973. Points denoted x were obtained by plotting sub-delta marsh rainfall figures and were used to project sub-delta water depth estimates.

Joanen and McNease (1972c, 1973b) and Palmisano *et al.* (1973) used 1970 nest count data as a basis for comparison with subsequent (1971-1973) nest counts and population estimates. The 1970 alligator population estimate was computed using a 67 percent value for nesting effort, and the assumption is thus implied that 67 percent of the adult females nested in 1970. Using 67 as the percentage of females nesting in 1970, and using the figures for percent decrease in nesting females supplied by Joanen and McNease (1972c) for the sub-delta and chenier plain marsh zones, values were computed for the percentages of mature females nesting in 1971 (Table 3).

Table 3.—Computed nesting effort as related to marsh water depths during May and June

Marsh zone	Year	Water depth [cm (feet)]	Percent mature females nesting
Chenier Plain	1970	32 (1.05)[a]	67.0
Sub-Delta	1970	20 (.65)[b]	67.0
Chenier Plain	1971	8 (.25)[a]	40.5[c]
Sub-Delta	1971	15 (.50)[b]	63.0[c]

[a] From Joanen *et al.* (1971).

[b] Derived from Figure 2 and rounded to the nearest 1.5 cm.

[c] Computed from percent changes in nesting success reported by Joanen and McNease (1972c).

The minimum value for percent nesting effort was rather arbitrarily assumed to be 33.5, or a 50 percent decrease from years of normal water level. Joanen and McNease (1972c) noted one nesting success change of −80 percent, but the area sampled was very small and the value was thus not used. It was further assumed that minimum nesting occurred at the marsh water depth of 0 cm, and this assumption should certainly be studied further. The minimum water depth at which 67 percent nesting effort occurs was set at 20 cm (.65 foot), as shown in Table 3. These data points were plotted and a curve was visually fit (Figure 3). In the model, the percentage of mature females nesting was determined from the curve, and this percentage was then applied to the number of mature females in the population at the end of June for each year.

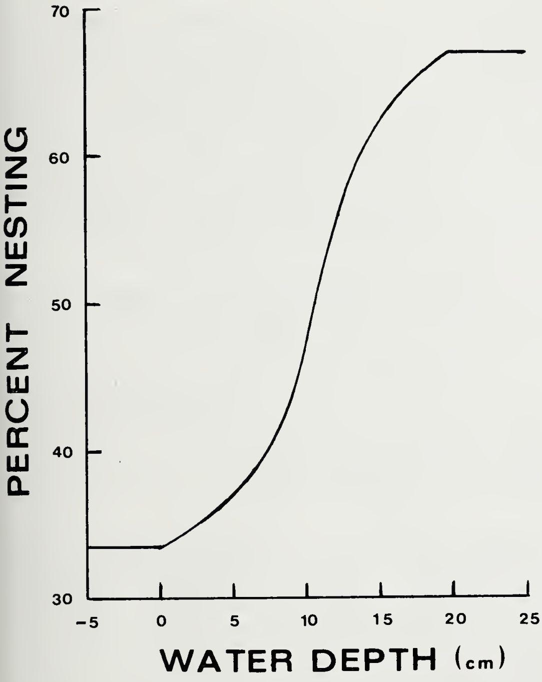

Figure 3.—Relationship between the percentage of mature female alligators nesting and marsh water depth (May-June average).

Nest Flooding

After nest construction and egg laying, alligator nests are vulnerable to flooding during times of high water. Flooding loss was reported to be a major source of egg mortality in the Florida Everglades (Hines *et al.* 1968) and can also cause considerable damage in Louisiana coastal marshland during certain years (Ensminger and Nichols 1957, Chabreck 1965).

The nest flooding-water depth relationship was obtained using data points from a variety of sources. In the model, the percentage of nests lost to flooding was determined as a function of the highest monthly water depth average of the three months June, July, and August. These are the three months during which eggs usually incubate. Joanen (1969) reported mean egg cavity measurements for alligator nests, and these data were used to obtain the maximum water depth at which no nest flooding would occur. Joanen's measurements indicate that a standing water depth of 26 cm (.85 foot) would reach the bottom of the first layer of eggs in the average nest. It was assumed that the average nest would lose some eggs to flooding at 27 cm (.9 foot). An arbitrary figure, 3 cm (.1 foot), was then subtracted from 27 cm (.9 foot), to partially account for nests which contained deeper egg cavities than average nests. The maximum value at which no eggs are lost to flooding was thus set at 24 cm (.8 foot).

Another data point was chosen using the 2.1 percent average nest flooding figure reported by Joanen (1969). June, July, and August water depths for the years of Joanen's study are shown in Table 1. Marsh water depths for three of these months averaged 27 cm (.9 foot), while the water depth for August 1966 averaged 34 cm (1.1 feet). The 2.1 percent flooding value represents six of Joanen's nests, and it was assumed that five of these nests were lost during the single month, August 1966. The five nests constituted approximately 8 percent of the nests followed during 1966.

Flemming (1974) followed 20 nests in the marsh and reported that 50 percent of these were flooded with a water depth of 37 cm (1.2 feet). Flemming's data apply only to marsh nests, and Joanen (1969) reported that 6.7 percent of the nests he observed were found on levees, above normal flood levels. Flemming's (1974) 50 percent figure was multiplied by Joanen's 93.3 percent marsh nesting figure, and it was calculated that 46.7 percent of all nests would be inundated with a water depth of 37 cm (1.2 feet).

Again using Joanen's (1969) egg cavity nest measurements, it was determined that all average marsh nests would be completely inundated with a water depth of 43 cm (1.4 feet). An additional 3 cm (.1 foot) was added to this value to include nests with relatively high egg cavities. It was thus calculated that a water depth of 46 cm (1.5 feet) would inundate all marsh nests, or 93.3 percent of the total nests. This figure is supported by data of Hines *et al.* (1968), who observed a 100 percent flooding loss of marsh nests with water depths of 55 cm (1.8 feet) and 70 cm (2.3 feet) in the Florida Everglades. Finally, it was assumed that all nests, including those built on levees, would be lost with water depths of 122 cm (4 feet) and greater. This 122 cm (4 feet) value is perhaps low and was simply intended to represent high marsh water levels associated with a hurricane. The various data points were plotted and lines were drawn to indicate a general nest flooding-water depth relationship (Figure 4). These baseline data can obviously be improved with further research efforts.

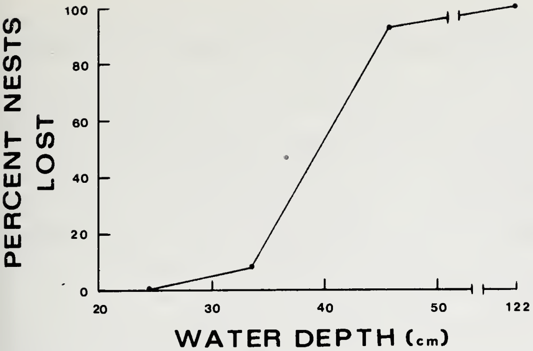

Figure 4.—Relationship between percent nest flooding and marsh water depth.

Levee Nesting

Levee nests apparently have different probabilities of being flooded and destroyed by predators than marsh nests, and it was thus important to investigate possible variability in the percentage of animals nesting on levees. Giles and Childs (1949) noted that adult females tended to use margins of ridges as nesting sites when marsh water levels were abnormally high. Ensminger and Nichols (1957) also reported increased nesting on levees in a year of high marsh water levels. However, Chabreck (1965) noted no relationship between nest location and water depth. Nesting alligators are very territorial and tend to nest in the same vicinity each year (Joanen 1969, Joanen and McNease 1970a). Joanen's (1969) 6.7 percent figure for levee nests was thus assumed to remain constant.

Nest Predation

Nest predation can be an important source of egg mortality. Joanen (1969) followed 266 nests during a 4-year period and reported that 16.5 percent of these nests were destroyed by raccoons, *Procyon lotor.* Joanen (1969) found that 50 percent of the levee nests he followed were taken by raccoons. Palmisano (pers. comm.) observed that 18-20 percent of all marsh nests are generally destroyed by raccoons, while approximately 50 percent of levee nests are destroyed.

Hines *et al.* (1968) reported the loss of one levee nest to a hog, *Sus scrofa.* Hogs are present in very low numbers in the southwestern Louisiana coastal marshes, and the number of alligator nests lost to them is insignificant. Kellogg (1929) reported finding three alligator eggs in the stomach of an alligator taken at Morgan City, Louisiana. Joanen (pers. comm.) noted that the stomach of a barren adult female alligator taken during the 1973 hunting season contained alligator eggs. These were isolated cases, however, and it is doubted that alligators are important nest predators.

The raccoon is by far the most important alligator nest predator, and it was the only predator considered in the model. Joanen (1969) found that nest predation by raccoons occurred just after the eggs began to crack along the longitudinal axis, usually after seven weeks of incubation. Joanen also noted that after locating a nest, raccoons would generally return every few days for three or four visits until all eggs had been eaten. A raccoon which located a nest after 49 days of incubation and periodically returned to the nest every few days, would probably finish with the nest at approximately the time of hatching. Therefore, it is unlikely that a raccoon would ever prey upon more than one nest per year, and certainly never more than two. Because of this temporal limitation of nest availability, it was hypothesized that the predation rate would not increase as a function of alligator nest density.

Raccoon density must certainly affect the rate of nest predation, but unfortunately this relationship could not be incorporated into the model. Raccoon density in the Louisiana coastal marsh varies from approximately one raccoon per 5 acres to one per 10 acres (Palmisano, pers. comm.). Unfortunately, raccoon density data were not available for years in which raccoon predation rates on alligator nests were known.

Flemming (1974) felt that nest predation is possibly related to marsh water depth, with higher predation rates occurring in dry years. He believed that raccoon predation on nests is probably linked to food availability, and that more food is available to raccoons during wet years. Unpublished data on annual 1965-1968 predation rates were made available by Joanen (pers. comm.), and these rates were compared with August marsh water depths. Percent predation was plotted against August marsh water depths, and three points were taken directly from Joanen's (pers. comm.) data. The lowest observed nest predation rate was 1.7 percent, which was reported in 1965 when the August marsh water depth averaged 6 cm (.2 foot). This predation rate seemed extremely low, and the 1.7 percent value was arbitrarily doubled to obtain a minimum predation rate of 3.5 percent. Flemming (1974) observed no nest predation on 20 nests he followed in 1973. The August marsh water depth during that year was 37 cm (1.2 feet). Therefore, the minimum predation rate of 3.5 percent was set to correspond with this water depth.

These data points were plotted, and lines were drawn to indicate the nest predation-water depth relationship (Figure 5). The portion of the graph lying above 24 cm (.8 foot) follows the pattern predicted by Flem-

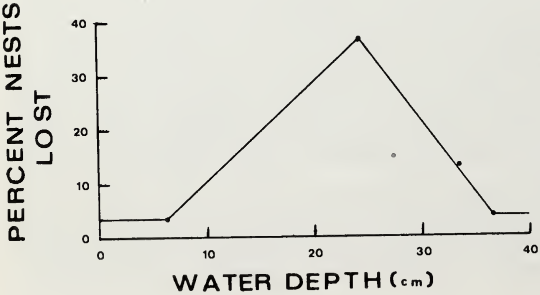

Figure 5.—Relationship between nest predation and marsh water depth.

ming (1974), with predation rate increasing as water level decreases. Below 24 cm (.8 foot), however, the relationship is contrary to what was expected.

If low predation rates do actually occur at low water levels, then such a relationship could be explained in several possible ways. The majority of alligator nests are built in the marsh interior, and perhaps during times of severe drought raccoons are less likely to leave large, permanent water sources and venture into the dry marsh in search of food. In times of drought, numerous raccoon prey species would probably be concentrated in any available bodies of water. Such a situation would eliminate the raccoon's need to venture into the interior marsh. Finally, most alligator nests are constructed near the female's hole or den, and females tend to remain near the den during periods of drought (Chabreck 1965). In a telemetric study of nesting females, Joanen and McNease (1970a) also noted that female movement was very restricted during the period of the year exhibiting the lowest water levels. By remaining in the proximity of the den and nest site during times of drought, females are probably better able to defend the nest against raccoons.

The relationship graphed in Figure 5 was used in the model, despite some doubts regarding the nature of the function. The inability to incorporate raccoon density into the model was unfortunate, and it is recommended that the raccoon density-nest predation relationship be studied in the future.

Hatching Success

Joanen (1969) found total hatching success to be 58.2 percent for 154 nests followed during 1967 and 1968. Joanen (1969) also reported a 4-year average predation and flooding loss value of 18.6 percent. This latter value was added to the total hatching success figure to obtain a survival rate for eggs which are not destroyed by nest predation and flooding. It was thus calculated that 76.8 percent of all eggs which survive predation and flooding hatch successfully. This value was incorporated into the model as a constant.

Alligator Population Structure and Mortality Relationships

Average Annual Mortality and Survival Rates

Before investigating alligator population structure and specific mortality functions, it was necessary to obtain average annual mortality rates for the different age classes in the alligator population. Alligator population dynamics have never been adequately studied, however, and no reliable mortality rate estimates could be found in the literature.

Chabreck (1966) presented night count results which indicated the size structure of the Rockefeller Refuge alligator population at the time of his study. This size structure could theoretically be used to construct a static or time-specific life table, and mortality rates could be obtained in this manner. Static life tables, however, require the assumptions that the environment does not change from year to year and that the population is at equilibrium (Krebs 1972), and neither of these assumptions could be met for the Rockefeller Refuge alligator population.

Harvest data were available for the 1972 and 1973 experimental seasons, and these data were manipulated to obtain one annual mortality estimate for 7-year-old males. This specific age and sex class was used because both 7- and 8-year-old males occupy single size classes, and mortality estimates for these animals are thus not confused by the existence of more than one age class per size category. The calculations invoked the assumption that 7-year-old males in 1972 and 8-year-old males in 1973 were harvested in proportion to their relative abundance in the sample population each year.

Two methods were used for taking alligators during the experimental harvest seasons, "fishing" with baited hook and line, and shooting. The fishing method was selective for larger animals (Palmisano *et al.* 1973), and it was decided to use only animals taken by this method in the calculations. The steps involved in the calculation of the 7-year-old male mortality rate are shown in Table 4. The final step involved subtracting the percent (25.30) mature male alligators caught by hook and line in the 1973, 2.1-2.4 meter (7-8 feet) size class, from the percent (32.11) mature male alligators caught by hook and line in the 1972, 1.8-2.1 meter (6-7 feet) size class. This difference of 6.81 percent was divided by 32.11 percent (again representing the 1.8-2.1 meter males in the 1972 sample) and a mortality rate of 21.2 percent was obtained.

After age 2, alligators are relatively free of most predation. Therefore, we assumed that mortality rates are the same for the alligator age classes 3-21, and the 21.2 percent annual mortality rate was considered to apply to all of these classes. After reaching maturity, female alligators move into the marsh interior, and their mortality rates probably decrease at this time (Chabreck 1965). Adult males, however, travel extensively (Joanen and McNease 1972b) and are subjected to a variety of hazards. Therefore, we assumed that adult males have twice the annual mortality rate of adult females.

The 21.2 percent annual mortality rate was broken down into seven equal monthly survival rates by solving for the equation $X^7 = (1-.212)$, and a .967 monthly survival rate was thus calculated. The .967 rate was applied to males and females aged 3 through 8 years. Assuming an adult sex ratio of 60.1 percent males (Chabreck 1966), differential annual survival rates were calculated to be .750 per year for males and .875 per year for females. The male mortality rate is therefore twice as high as the female rate. The annual survival rates reduce to .960 per month

Table 4.—Mortality rate calculations for seven-year-old males

Size class [meters (feet)]	Percent alligators caught by hook & line[a]	Percent alligators which were males[b][c]	Percent alligators which were caught by hook & line which were males	Total number of alligators harvested[d][e]	Number of male alligators caught by hook & line	Percent mature male alligators caught by hook & line in each size class
	1972 Harvest					
1.8-2.1 (6-7)	75.00	82.43	61.82	327	202	32.11
2.1-2.4 (7-8)	79.17	70.00	55.42	288	160	25.44
2.4-2.7 (8-9)	79.31	93.55	74.19	149	111	17.65
2.7-3.0 (9-10)	96.67	100.00	96.67	93	90	14.31
3.0-3.4 (10-11)	88.24	100.00	88.24	57	50	7.95
3.4-3.7 (11-12)	66.67	100.00	66.67	16	11	1.75
3.7+ (12+)	100.00	100.00	100.00	5	5	0.79
	1973 Harvest					
1.8-2.1 (6-7)	75.00	47.06	35.30	724	256	23.38
2.1-2.4 (7-8)	79.17	62.11	49.17	564	277	25.30
2.4-2.7 (8-9)	79.31	77.27	61.28	323	198	18.08
2.7-3.0 (9-10)	96.67	97.14	93.91	176	165	15.07
3.0-3.4 (10-11)	88.24	100.00	88.24	139	123	11.23
3.4-3.7 (11-12)	66.67	100.00	66.67	90	60	5.48
3.7+ (12+)	100.00	100.00	100.00	16	16	1.46

[a] Source: Table 4 of Palmisano *et al.* (1973).

[b] Source (1972 data): Table 5 of Palmisano *et al.* (1973).

[c] Source (1973 data): McNease (pers. comm.).

[d] Source (1972 data): Table 3 of Palmisano *et al.* (1973).

[e] Source (1973 data): Table 1 of Joanen *et al.* (1973).

for males and .981 per month for females, and were applied to animals 9 through 21 years old.

Based on field observations of alligator populations, we estimated an average 65 percent mortality rate for 1-year-old animals and a 40 percent mortality rate for 2-year-olds. Both sexes are equally vulnerable at these ages, and average monthly survival rates were calculated to be .861 for 1-year-olds and .930 for 2-year-olds. Average annual and monthly survival rates are summarized in Table 5. As previously mentioned, all annual survival rates were broken down into seven monthly rates. It was assumed that all alligator mortality sources other than freezes occurred during the months April through October. The alligators were considered to be semidormant during the five months November through March, and few mortality sources probably operate during this period.

Table 5.—Average alligator survival rates

	Annual survival rate		Monthly survival rate	
Age	Male	Female	Male	Female
1	.350	.350	.861	.861
2	.600	.600	.930	.930
3	.788	.788	.967	.967
4	.788	.788	.967	.967
5	.788	.788	.967	.967
6	.788	.788	.967	.967
7	.788	.788	.967	.967
8	.788	.788	.967	.967
9	.750	.875	.960	.981
10	.750	.875	.960	.981
11	.750	.875	.960	.981
12	.750	.875	.960	.981
13	.750	.875	.960	.981
14	.750	.875	.960	.981
15	.750	.875	.960	.981
16	.750	.875	.960	.981
17	.750	.875	.960	.981
18	.750	.875	.960	.981
19	.750	.875	.960	.981
20	.750	.875	.960	.981
21	.750	.875	.960	.981

Population Age Structure

A general knowledge of the age structure of the alligator population was necessary before various mortality functions could be calculated. Chabreck (1966) presented results of night count surveys which indicated the size structure of the Rockefeller Refuge alligator population (Table 6). Chabreck believed his sample to be representative and combined his night count results with nest count data to estimate the total alligator population of Rockefeller Refuge.

Table 6.—The results of night counts and total population computation for alligators on Rockefeller Wildlife Refuge, 1966[a]

Total length size class [meters (feet)]	Number seen	Percentage composition	Total number on refuge
.3- .6 (1-2)	45	25.3	1,339
.6-.9 (2-3)	33	18.5	979
.9-1.2 (3-4)	30	16.8	888
1.2-1.5 (4-5)	24	13.5	714
1.5-1.8 (5-6)	18	10.1	534
1.8-2.1 (6-7)	13	7.3	386
2.1-2.4 (7-8)	8	4.5	238
2.4-2.7 (8-9)	4	2.3	122
2.7-3.0 (9-10)	2	1.1	58
3.0+ (10+)	1	.6	32
Total	178	100.0	5,291

[a] Source: Table 2 of Chabreck (1966).

Chabreck's (1966) night count data indicated the size structure of the alligator population at approximately the end of May and the beginning of June, 1966. Our calculations required a knowledge of September age structure, however, and because of the differential mortality rates operating on the population, the September size structure is expected to differ from the June size structure. It was, therefore, necessary to "back the population up" from June 1966 to September 1965. This was accomplished by dividing the number of animals comprising each size class,

Table 7.—Size-specific sex ratios used in the construction of alligator population structures[a]

Total body length	Males	Females
Meters (feet)	———————— Percent	———————
.3- .6 (1-2)	60.1[b]	39.9
.6- .9 (2-3)	64.6	35.4
.9-1.2 (3-4)	62.8	37.2
1.2-1.5 (4-5)	53.5	46.5
1.5-1.8 (5-6)	52.4	47.6
1.8-2.1 (6-7)	64.1	35.9
2.1-2.4 (7-8)	60.1[c]	39.9
2.4-2.7 (8-9)	60.1[c]	39.9
2.7-3.0 (9-10)	60.1[c]	39.9
3.0-3.4 (10-11)	100.0	0.0
3.4-3.7 (11-12)	100.0	0.0
3.7+ (12+)	100.0	0.0

[a] Unless otherwise indicated, sex ratio data were obtained from 1,816 alligators captured alive in Louisiana from April 1959 to December 1966 (Chabreck unpubl. data).

[b] Average adult sex ratio (Chabreck 1966) was used because of inability to sex young alligators.

[c] Average adult sex ratio (Chabreck 1966) was used because of insufficient data (small sample sizes).

by the monthly size-specific survival rate taken to the fourth power (there are four months involved). For example, the number of .9-1.2 meter (3-4 feet) alligators in the June population was 888, so the number of .9-1.2 meter animals in the September population was equal to $888/(.967)^4=1{,}016$. These calculations yielded a new size structure characteristic of the beginning of September.

The September population size structure was then broken down by sex according to size-specific sex ratios (Table 7). These ratios were obtained from 1,816 alligators captured alive in Louisiana during the period 1959-1966. It is virtually impossible to accurately determine the sex of alligators less than .6 meter (2 feet) in length, and the average adult value of 60.1 percent males (Chabreck 1966) was thus used for these small animals. The 60.1 percent male value was also used for size classes in which the number of animals examined was insufficient.

Finally, it was necessary to determine the number of animals in each age class, within a given size and sex class. This was accomplished by assuming a stable age distribution within each size class and by solving the following equation for X:

$$\sum_{i=0}^{n} (Y)^i X = X + YX + (Y)^2 X + \ldots + (Y)^n X = Z$$

where n−1 equals the number of age classes in the given size class, Y equals the annual survival rate, Z equals the total number of animals in the size class, and X equals the number of animals in the youngest age class within the size class. The sizes of subsequent age classes within a size class were then obtained by multiplying the number of animals in the youngest age class by the appropriate power of the survival rate.

An example of the type of age structure derived from the calculations is presented in Table 8. This particular age structure was obtained starting with the June 1973 population estimate of 71,897 animals (Palmisano *et al.* 1973). The derived age structure contains 96,918 alligators and represents the September 1972 population.

Table 8.—Calculated age structure, September 1972

Age	Males	Females	Age	Males	Females
1	19,876	13,196	12	415	652
2	11,487	6,295	13	174	514
3	8,680	5,141	14	137	406
4	5,942	2,888	15	93	209
5	2,435	2,276	16	74	166
6	1,919	1,642	17	11	130
7	3,315	1,294	18	8	103
8	2,043	1,019	19	7	81
9	609	1,059	20	6	64
10	479	834	21	4	50
11	528	657			

Specific Mortality Functions

After obtaining a general knowledge of population age structure and average mortality rates, it became possible to examine specific mortality relationships. Drought can result in increased desiccation, predation, and cannibalism mortality in alligators (Hines *et al.* 1968, Spotila *et al.* 1972, Truslow *et al.* 1967). A severe drought can be characterized by a marsh water level of −61 cm (−2.0 feet) for a period of 2 months, and such a drought can increase normal mortality by an estimated 20 percent. An estimated 60 percent of such a drought loss would probably be suffered by 1-year-old animals, 30 percent by 2-year-olds, and the remaining 10 percent by females and other immature males. The adult males inhabit the large bodies of permanent water and would be relatively unaffected by drought. Using these estimates and a September age structure (Table 8), drought mortality rates were calculated for the specified age classes. These rates indicate the percentages by which normal mortality rates are increased during a 2-month drought. These drought rates were simply divided by 2, and monthly rate increases were obtained.

Desiccation.—Alligators have high rates of evaporative water loss and are threatened by desiccation during times of drought (Spotila *et al.* 1972). We estimated that 50 percent of the total drought mortality results from desiccation, while the remaining 50 percent results from predation and cannibalism. The total monthly drought rates were thus divided by 2 to obtain desiccation mortality rates for a month of −61 cm (−2.0 feet) marsh water level. Because of the probable relationship of alligator size to mobility and desiccation vulnerability, the estimated minimum water levels at which no desiccation mortality occurs differ among the three affected age classes. The hypothesized desiccation mortality-water depth relationships have been plotted in Figures 6, 7, and 8.

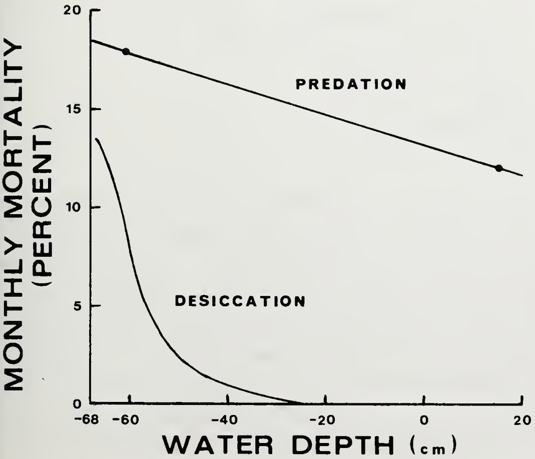

Figure 6.—Relationship between both predation and desiccation mortality and marsh water depth in 1-year-old alligators.

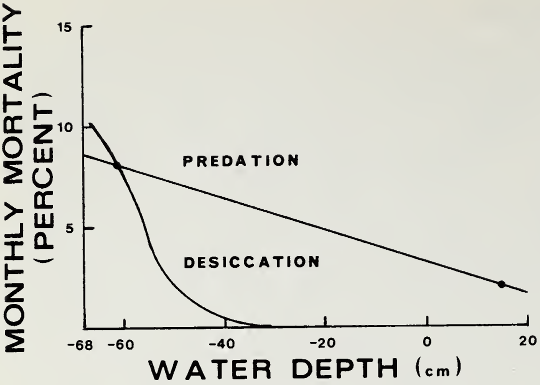

Figure 7.—Relationship between both predation and desiccation mortality and marsh water depth in 2-year-old alligators.

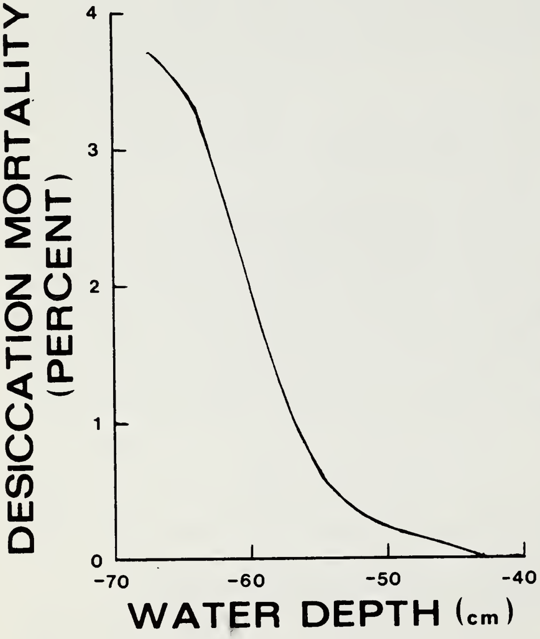

Figure 8.—Relationship between desiccation mortality and marsh water depth in female alligators aged 3-21 years and male alligators aged 3-6 years.

Cannibalism.—Instances of alligator cannibalism have been reported by Kellogg (1929), Giles and Childs (1949), Valentine *et al.* (1972), and Truslow *et al.* (1967), and this mortality source is probably the major density dependent factor operating on Louisiana alligator populations. During years of normal water level cannibalism results in an estimated 2 percent annual mortality rate at present population densities, and in a 6 percent annual mortality rate at carrying capacity densities.

Carrying capacity estimates for the coastal marshland of Cameron and Vermilion parishes are one alligator per five acres of fresh marsh, one alligator per eight acres of intermediate marsh, and one alligator per 20 acres of brackish marsh. These carrying capacity figures represent population densities on wildlife refuges in the study area with long histories of rigidly protected alligator populations. The total acreage of each marsh type in the study area was divided by the appropriate carrying capacity (acres per alligator) figure. Then, the carrying capacity populations for each marsh type were summed, and a total carrying capacity figure of 147,590 alligators was obtained for the 1,144,600-acre study area.

Assuming that 60 percent of all cannibalism mortality is suffered by 1-year-olds, 30 percent by 2-year-olds, and 10 percent by 3-year-olds, monthly cannibalism mortality rates were calculated for present population densities and carrying capacity densities at average water depths. Present population density was assumed to be about 71,900 (Palmisano *et al.* 1973), and carrying capacity density was again assumed to be 147,590 animals. The density-cannibalism relationship was then plotted (Figure 9). It was assumed that cannibalism would never decrease to 0, and a minimum cannibalism rate was thus arbitrarily set at .001.

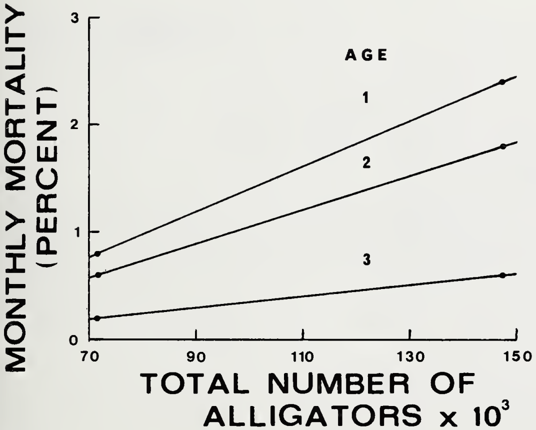

Figure 9.—Relationship between cannibalism mortality and total density in the alligator population of Cameron and Vermilion parishes, Louisiana.

Alligators become concentrated as water levels decline and, during years of severe drought, we estimated 5 and 15 percent cannibalism mortality rates for present density and carrying capacity density populations, respectively. These severe drought cannibalism mortality rates are each 2.5 times as large as average water depth rates for the respective population densities. A severe drought cannibalism rate increase was calculated using annual average water and severe drought cannibalism rate estimates and a September age structure. This total severe drought cannibalism rate increase was then divided by 2 (the number of months involved in a severe drought), and an overall monthly rate increase was obtained.

Age-specific monthly severe drought cannibalism rate increases were calculated for the three affected age classes using a September age structure and the previously calculated cannibalism rates for average water depth and present density. These age-specific rate calculations invoked the assumption that severe drought cannibalism increases are proportional for the three affected age classes. In this manner, it was calculated that normal monthly cannibalism rates are increased by a factor of 4.65 during months of severe drought. A cannibalism rate multiplier was then plotted by setting 4.65 to correspond with a water level of −61 cm (−2.0 feet), and setting the value 1 to correspond with the average water depth of 15 cm (.5 foot) (Figure 10). A minimum value for this multiplier was arbitrarily assumed to be .25, because it was felt that the cannibalism rate would never decrease to 0.

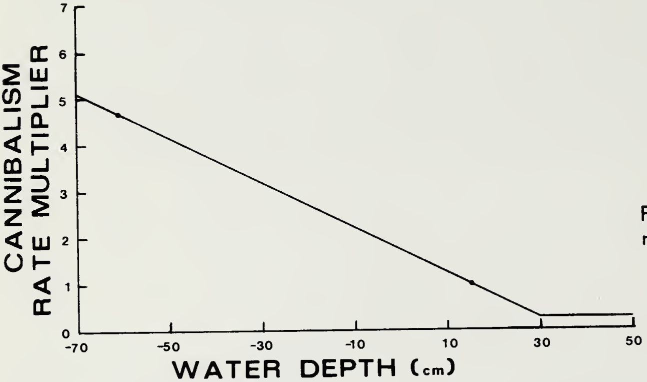

Figure 10.—Cannibalism rate multiplier function.

In the model, the monthly cannibalism mortality rate was determined as a function of density. This rate was then multiplied by the cannibalism rate multiplier, which was determined as a function of monthly water level. The resulting product constituted the increase in mortality due to cannibalism.

Predation.—Alligator young are preyed upon by a wide variety of predators (Neill 1971), and because of the variety it was impossible to incorporate predator densities into the model. Predation rates are probably also a function of alligator density, but again this relationship was not included in the model because of insufficient data. We estimated that during years of average water depths, 1-year-old alligators would suffer approximately a 60 percent loss to predators. We estimated that 2-year-old animals would lose 15 percent annually due to predation. These annual age-specific predation rates were converted to monthly rates in the manner previously described.

During times of drought, alligator young and predators are concentrated in remaining water bodies, and alligators suffer high predation rates (Hines *et al.* 1968). As has been previously mentioned, we estimated that 50 percent of the total alligator mortality suffered during a severe drought (water level at −61 cm for 2 months) could be attributed to predation and cannibalism. The drought cannibalism rates were determined for each affected age class as previously described, and the drought predation rates were obtained by subtracting the cannibalism rates from the total predation plus cannibalism rates. The predation rate-water depth relationships have been plotted in Figures 6 and 7. It was assumed that predation would never decrease to 0, and minimum monthly predation mortality rates of .05 and .01 were thus set for 1- and 2-year-old alligators, respectively.

Natural Mortality.—In the model, natural mortality is simply an age and sex-specific constant which includes all mortality sources in addition to those already separated from the average mortality values. Natural mortality includes such mortality sources as animals being shot as pests, animals being poached for skin or meat, animals being hit by boats and automobiles and killed accidentally, and animals dying from physiological mortality sources unrelated to drought. Natural mortality rates were obtained by subtracting age and sex-specific cannibalism and predation mortality rates (for months of average water depth) from average total mortality rates. These age and sex-specific rates were then incorporated into the model as constants.

Freeze Mortality.—Chabreck (1965) reported finding dead alligators ranging from .6 to 3.0 meters (2 to 10 feet) in length which had suffocated under ice during a severe freeze in January 1962. Climatological records indicate that in January 1962 the maximum temperature for Lake Charles, Louisiana, was below O°C. for a period of between 2 and 3 days. It was assumed in the model that any drop in maximum temperature below O°C. for a period of 2 days or more would cause alligator freeze mortality. Such a freeze was set to produce a 5 percent loss from the total population and was considered to be neither age nor sex-specific.

Hunting Mortality.—One of the major objectives of this study was to investigate the effects of hunting mortality on alligator populations, and the model included an optional harvest rate which could be applied to the population in September of each year. In the model, the overall optional harvest rate was used to calculate relative age and sex-specific harvest rates similar to those observed in the 1972 and 1973 Louisiana seasons. The calculations involved the use of size and sex-specific harvest percentages which were obtained by summing all wild animals taken in the two Louisiana seasons (from Joanen *et al.* 1972, Palmisano *et al.* 1973, Joanen *et al.* 1973, McNease pers. comm.) and determining the percent composition of this total for each size and sex class (Table 9). The actual calculation of harvest rates in the model is described elsewhere.

Harvest regulations for the 1972 and 1973 seasons were designed to protect mature female alligators. A lower size limit of 1.2 meters (4 feet) total body length was also established to protect young animals. Complete discussions of the regulations governing these two seasons are

Table 9.—Percent composition of the combined 1972 and 1973 Louisiana alligator harvest[a]

Total body length	Males	Females
Meters (feet)	———————Percent——————	
1.2-1.5 (4-5)	5.93	3.77
1.5-1.8 (5-6)	13.68	6.87
1.8-2.1 (6-7)	14.34	10.30
2.1-2.4 (7-8)	12.99	7.03
2.4-2.7 (8-9)	9.14	1.93
2.7-3.0 (9-10)	6.36	
3.0-3.4 (10-11)	4.64	
3.4-3.7 (11-12)	2.49	
3.7+ (12+)	.53	

[a] Data used to calculate these percentages were taken from Tables 3 and 5 of Palmisano *et al.* (1973), Table 1 of Joanen *et al.* (1973), and a table provided by McNease (pers. comm.). Data on total size composition of harvests were corrected to eliminate farm alligators from the computations.

found in Joanen and McNease (1972d) and Palmisano *et al.* (1973). Since the Louisiana hunters apparently selected for large animals (Palmisano *et al.* 1973), the observed harvest rates will subsequently be referred to as "differential" rates (i.e., differential with respect to size and age).

In the model, it was assumed that alligator populations do not adjust to hunting mortality with compensatory reductions in natural mortality. This assumption was made because of a lack of contrary evidence but may very well be false. Because of the nature of this assumption, our simulated hunting produced maximum detrimental effects on the population.

THE SIMULATION MODEL

Description

A mechanistic mathematical model was constructed to simulate the behavior of the population over time, employing techniques derived from systems science theory as applied to the modeling of ecological systems. The system was defined as the alligator population existing in the area studied, and was divided into components which grouped the population into developmental stages according to age. This was done for each sex. In order to implement the model it was necessary to group the animals in the matrix fashion presented in Table 10, where each element corresponds to a population component. The structure of the model incorporated the use of state equations for each component describing its behavior in terms of stimulus and response variables, the state variable being the number of animals in a particular age and sex class. Initial values for the state variables were chosen for experimental simulations from a set of initial age structures. Behavioral features were chosen to be the number of deaths (mortality), the number of females which nest (reproduction), and the number of animals leaving the developmental stage (growth). These features were response variables for the population component. The only endogenous stimulus feature used was the number of animals entering the developmental stage through growth or birth. Stimulus variables exogenous to the system were average monthly water levels, temperature, and a harvest rate equal to the percentage of animals taken by hunters.

Table 10.—Grouping of population components

Age of animal[a]	Assigned age class	Subscript for AGEINIT	
		Males	Females
0-1	1	(1,1)	(1,2)
1-2	2	(2,1)	(2,2)
2-3	3	(3,1)	(3,2)
3-4	4	(4,1)	(4,2)
4-5	5	(5,1)	(5,2)
5-6	6	(6,1)	(6,2)
6-7	7	(7,1)	(7,2)
7-8	8	(8,1)	(8,2)
8-9	9	(9,1)	(9,2)
9-10	10	(10,1)	(10,2)
10-11	11	(11,1)	(11,2)
11-12	12	(12,1)	(12,2)
12-13	13	(13,1)	(13,2)
13-14	14	(14,1)	(14,2)
14-15	15	(15,1)	(15,2)
15-16	16	(16,1)	(16,2)
16-17	17	(17,1)	(17,2)
17-18	18	(18,1)	(18,2)
18-19	19	(19,1)	(19,2)
19-20	20	(20,1)	(20,2)
20-21	21	(21,1)	(21,2)

[a] Expressed in years.

The model was basically deterministic and was modified in some experimental simulations to produce a model which was stochastic with respect to environmental factors. Stochastic parameters were monthly water levels and temperature. Values for water levels (expressed in feet) were randomly generated from a normal distribution about the mean for each month (from Table 1). Twelve random numbers between 0 and 1 were generated by a computer library function. The value 6 was subtracted from the sum of these numbers to give a mean value of 0. This number was then multiplied by the standard deviation of the monthly water level (Table 1), and the resulting value was added to the mean value for that month, giving the water level used in the response equations. Temperature was considered only through the use of a factor representing a freeze during winter, with probability of occurrence equal to .1 (once every 10 years). The freeze factor was designated to occur if the value of one random number generated by the computer library function was less than or equal to .1, where again the range of values was from 0 to 1.

To observe the dynamics of the population over a time period of several years, the month of September was treated as the beginning of a new year, representing T = 1 in the equations below. September was chosen due to the assumption that all eggs were hatched at the end of August. The months November through March were treated as one time block and designated as winter. All rates affecting the stimulus variables were applied during the months April through October unless otherwise designated.

State equations used to describe component behavior were:

(1) [AGEINIT(i,j)](T+DT)= [[AGEINIT(i,j)] (T) x SURNATM X HUNSURV] x DT; for i = 1,21; j = 1,2; and T = 0,11

(2) [AGEINIT(i,j)](T+DT) = [[AGEINIT (i—1,j)] (T)] x DT; for i = 2,21; j = 1,2; and T = 11

(3) [AGEINIT(i,j)](T+DT) = [HACHTOT x .601] x DT; for i =1; j = 1; and T =11

(4) [AGEINIT(i,j)](T+DT) = [HACHTOT x .399] x DT; for i = 1; j = 2; and T = 11

where AGEINIT was the state variable which was used to represent the number of animals in component (i,j), and DT was the time interval, chosen to equal one month. Thus the end of the current month occurred at time T + DT, and DT assumed a constant value of 1.

Monthly Population Changes During April Through October

State variables were updated monthly by state equation (1). SURNATM was a total survival rate including survival from all mortality factors with the exception of harvesting. This rate was determined by the following equation, where APRED was a predation rate for the young, CANNAB was a cannibalism mortality rate, DESS was a desiccation mortality rate, and NATURAL was a natural mortality rate:

SURNATM = 1—(APRED+CANNAB+DESS+NATURAL)

APRED and DESS were computed as functions of average monthly water levels. CANNAB was used as the only density dependent factor in the model, and thus a function of the total population (CANN) was computed and then multiplied by a factor (CANNMUL) which was determined as a function of the average monthly water level. The above rates were determined by the following equations, where WATER corresponded to the average monthly water level (expressed in feet), and TOTAL was equal to the total population. All rates not applicable to a component were assigned default values which were set so as to have no influence on the function value.

$\text{CANNMUL} = -1.46(\text{WATER}) + 1.73$ (see Figure 10)
$\text{CANNAB} = \text{CANNMUL}\,(\text{CANN})$

Response equations for age class 1:
$\text{APRED} = -.0236\,(\text{WATER}) + .1318$ (see Figure 6)
for $\text{WATER} \leq 3.46$
$\text{APRED} = .05$ (see Figure 6)
for $\text{WATER} > 3.46$
$\text{CANN} = .00000021\,(\text{TOTAL}) - .0071$ (see Figure 9)
for $\text{TOTAL} > 38600$
$\text{CANN} = .001$ (see Figure 9)
for $\text{TOTAL} \leq 38600$

Response equations for age class 2:
$\text{APRED} = -.0240\,(\text{WATER}) + .0320$ (see Figure 7)
for $\text{WATER} \leq .91$
$\text{APRED} = .01$ (see Figure 7)
for $\text{WATER} > .91$
$\text{CANN} = .00000016\,(\text{TOTAL}) - .0055$ (see Figure 9)
for $\text{TOTAL} > 40600$
$\text{CANN} = .001$ (see Figure 9)
for $\text{TOTAL} \leq 40600$

Response equations for age class 3:
$\text{CANN} = .00000005\,(\text{TOTAL}) - .0016$ (see Figure 9)
for $\text{TOTAL} > 52000$
$\text{CANN} = .001$ (see Figure 9)
for $\text{TOTAL} \leq 52000$

In addition to the above rates, NATURAL was applied to all age classes, and DESS was applied to males in age classes (1-6) and to all females. Natural mortality rates (NATURAL) are presented in Table 11 and were calculated as previously described. DESS values were derived from Figures 6, 7, and 8 and were included in the model in tabular form.

HUNSURV was a survival rate obtained from harvest mortality rates and was applied to age classes (4-21) during the month of September only. Calculation of these survival rates involved a series of steps in the model. First, a total was obtained for all animals of harvestable size (ages 4-21). The total number of harvestable animals was then multiplied by the desired overall hunting rate (HUNRATE) to obtain the total number of animals to be harvested from all age classes (HARTOT). The next step involved the use of size and sex-specific harvest percentages (see Table 9) which were read into the program as HUNTING (I). In the model, HUNTING (I) was multiplied by HARTOT to obtain the number of animals to be harvested from each size and sex class (HARNUM (I)). The values for HARNUM(I) were then subtracted from the

Table 11.—Natural mortality rates

Age class	NATURAL Males	NATURAL Females	Age class	NATURAL Males	NATURAL Females
1	.011	.011	12	.043	.020
2	.044	.044	13	.043	.020
3	.031	.031	14	.043	.020
4	.033	.033	15	.043	.020
5	.033	.033	16	.043	.020
6	.033	.033	17	.043	.020
7	.033	.033	18	.043	.020
8	.033	.033	19	.043	.020
9	.043	.020	20	.043	.020
10	.043	.020	21	.043	.020
11	.043	.020			

number of animals comprising each size and sex class (TOTSIZE(I)) to obtain the number of hunting survivors. The number of survivors was divided by TOTSIZE (I) to obtain hunting survival rates for each size and sex class (SURHUNM (I,J)). HUNSURV was finally set equal to the SURHUNM values of the appropriate age and sex classes.

Monthly Changes During November Through March

At the beginning of winter, T (see state equation 1) was automatically incremented by 4DT to give the value T = 7, which represented the end of March, and the state variables were updated. It was assumed that the only rate affecting the population component during this time period was a freeze mortality. If the freeze factor was applied, SURNATM was set to equal 95 percent for each component. If no freeze occurred, there was no change in the population.

Yearly Population Changes

State equation (2) was used to update the state variables for age classes (2-21) at the end of each year. The number of animals leaving a component became the number of animals entering the next developmental stage. The last age class was simply "dropped" due to the assumption that no animals survived past age 21.

State equations (3) and (4) were used to compute the number of male and female hatchlings, respectively. HACHTOT represented the total number of eggs hatched, and was expressed by the following equation:

$$\text{HACHTOT} = [(\text{EGGS}(1-\text{NESTFLD})) \times (1-\text{PRED})] \times .768$$

Rates contained in this equation were applied at the end of August.

EGGS was used to represent the total number of eggs laid, NESTFLD was a rate which represented egg mortality due to nest flooding, and PRED was a raccoon nest predation rate. A survivorship constant equal to 76.8 percent was applied to all eggs surviving predation and nest flooding. EGGS was computed by summing the number of eggs produced by each adult female age class (classes (9-21)), which was dependent upon the population component size (AGEINIT) and nesting effort (NESTEFF). NESTEFF was used to represent the percentage of females which nest (reproductive rate) as a function of the average water depth for May and June. This rate was applied only at the end of June, when it was multiplied by the number of females in each reproducing class to yield the total number of nesting females in that class (REPRATE). REPRATE was then multiplied by the average number of eggs laid per female, which was assumed to be 38.9, giving total eggs produced by that population component. The percentage of eggs lost due to flooding of nests (NESTFLD) was determined to be a function of the maximum value of June, July, and August water depths. NESTFLD attained values derived from Figure 4. Equations used to describe raccoon predation on the eggs as a function of August water levels were:

$\text{PRED} = .035$ (see Figure 5)
for $\text{WATER} < .2$ or $\text{WATER} > 1.2$
$\text{PRED} = .55\,(\text{WATER}) - .075$ (see Figure 5)
for $.2 \leq \text{WATER} \leq .8$
$\text{PRED} = -.825\,(\text{WATER}) + 1.025$ (see Figure 5)
for $.8 < \text{WATER} \leq 1.2$

The number of male hatchlings was assumed to be 60.1 percent of the total, and the number of females was assumed to be 39.9 percent. These rates were multiplied by HACHTOT to give the number of males and females entering the first age class.

The new age structure resulting at the end of the simulated year became the new initial age structure for the start of the next year.

Implementation

The model was implemented by a Fortran program on the Control Data 6500 computer system. Block diagrams for the computations are shown in Figure 11. A complete listing of one version of the program is contained in the Appendix, Pages 55-59.

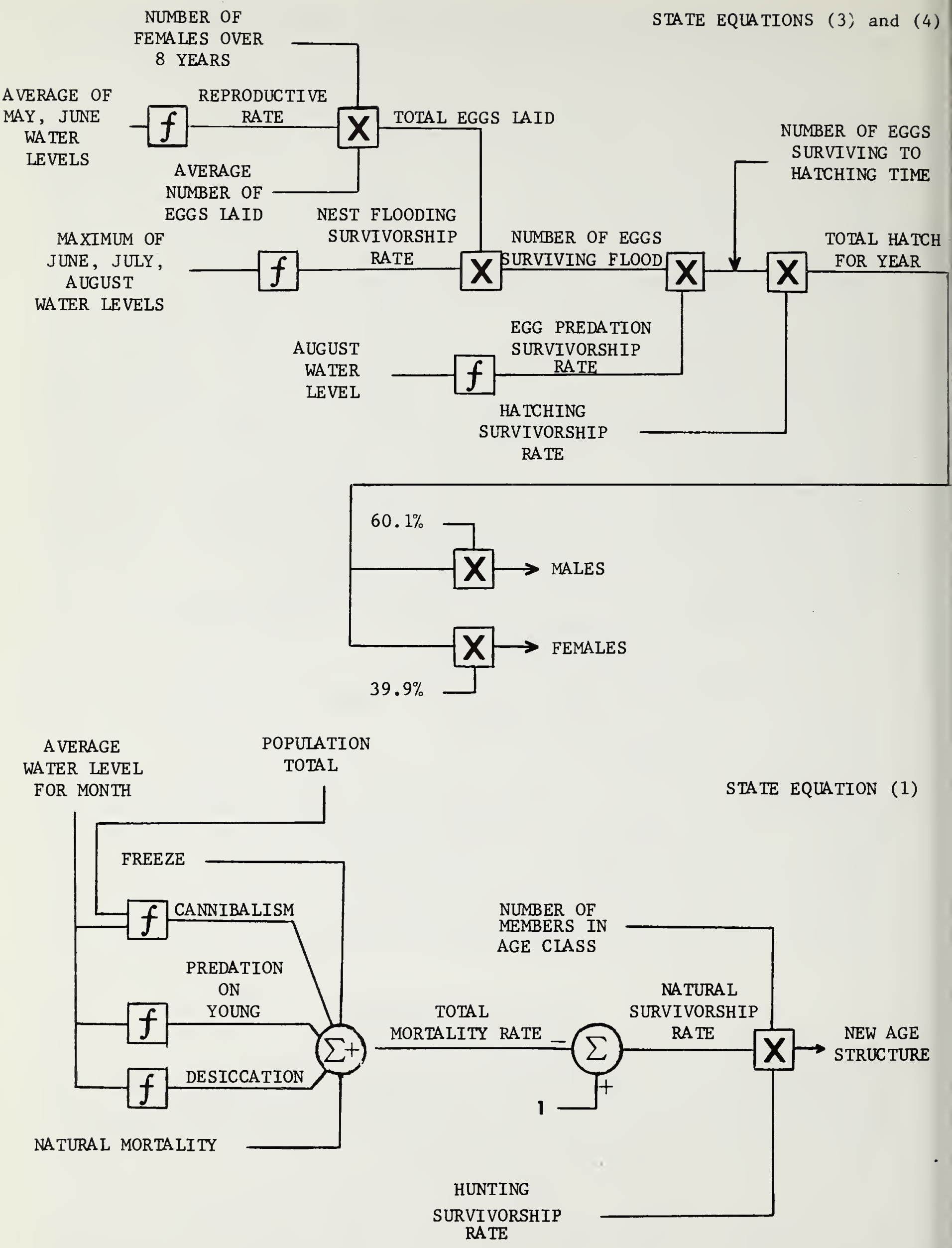
STATE EQUATIONS (3) and (4)
NUMBER OF FEMALES OVER 8 YEARS
AVERAGE OF MAY, JUNE WATER LEVELS
f
REPRODUCTIVE RATE
X
TOTAL EGGS LAID
AVERAGE NUMBER OF EGGS LAID
NUMBER OF EGGS SURVIVING TO HATCHING TIME
MAXIMUM OF JUNE, JULY, AUGUST WATER LEVELS
NEST FLOODING SURVIVORSHIP RATE
NUMBER OF EGGS SURVIVING FLOOD
TOTAL HATCH FOR YEAR
AUGUST WATER LEVEL
EGG PREDATION SURVIVORSHIP RATE
HATCHING SURVIVORSHIP RATE
60.1%
MALES
FEMALES
39.9%
AVERAGE WATER LEVEL FOR MONTH
POPULATION TOTAL
STATE EQUATION (1)
FREEZE
CANNIBALISM
PREDATION ON YOUNG
DESICCATION
Σ+
NATURAL MORTALITY
NUMBER OF MEMBERS IN AGE CLASS
TOTAL MORTALITY RATE
_
Σ
+
1
NATURAL SURVIVORSHIP RATE
NEW AGE STRUCTURE
HUNTING SURVIVORSHIP RATE

Figure 11.—Block diagram of model state equations.

RESULTS AND DISCUSSION

Alligator Population Structure

Preliminary population growth simulations were run using a September initial age structure (Table 8) calculated from Chabreck's (1966) observed May-June size structure. Results of one such 20-year simulation with constant 15 cm (.5 foot) water depths are presented in Figure 12. Irregularities in this population growth curve (Figure 12) resulted from inadequacies or inconsistencies in the initial age structure. The high population growth rate for year 1 can be directly attributed to the introduction of a "normal" complement of hatchlings at the end of that year. The other major irregularity in the population growth curve occurred during year 9, the year in which hatchling females from the initial age structure reached sexual maturity. Simulation results thus suggested an inadequate representation of animals in the first age class of the initial age structure. Analysis of Chabreck's (1966) field data provided additional support for the contention that hatchlings were underestimated in the derived September age structure. Calculations assuming (1) average egg mortality and hatching success (from Joanen 1969), (2) equivalent hatchling mortality rates from September to May and from June to September, and (3) a stable age distribution (this had probably not been achieved), yielded an unrealistically low number of 1-year-old survivors for September 1966.

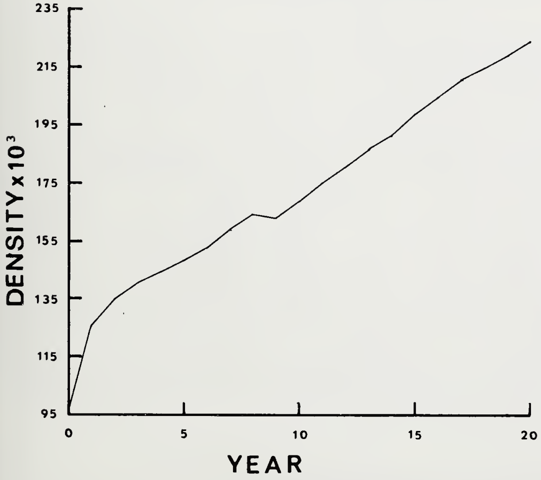

Figure 12.—Simulated population growth using the September initial age structure shown in Table 8. Water depths were held constant at 15 cm (.5 foot) and no winter freezes occurred.

Because of this apparent underrepresentation of hatchlings, the use of the Table 8 age structure in experimental simulations would have caused problems in interpreting population response curves. For example, it would have been difficult to separate effects of the irregular age structure from effects of experimental manipulations (such as variations in hunting pressure or environmental parameters) in such response curves. Therefore, the initial proportions of animals in each age and sex class for all subsequent computer runs were based on the population structure generated by the 20-year simulation (Figure 12). An example of this computer-generated age structure is shown for an initial population of 100,000 in Table 12.

Table 12.—Computer-generated initial age structure for a population of 100,000

Age	Males	Females	Age	Males	Females
1	30,551	20,283	12	353	386
2	8,962	5,950	13	273	353
3	4,733	3,142	14	201	306
4	3,587	2,382	15	138	248
5	2,777	1,844	16	100	214
6	2,140	1,421	17	73	183
7	1,660	1,102	18	53	158
8	1,289	856	19	39	136
9	996	661	20	29	118
10	710	557	21	12	53
11	504	467	Total	59,180	40,820

Model—Field Data Comparison

Nest counts conducted in the years 1970-1973 (Joanen and McNease 1970b, 1972c, 1973b; Palmisano *et al.* 1973) provided an opportunity to test the model against observed field data. A computer-generated initial age structure was constructed such that the number of nests produced the first year (using observed 1969-1970 marsh water depths) closely approximated the 1970 aerial nest count (percent error = .08). The simulation was then run for three additional years with observed 1970-1973 water depth inputs (Table 1), and the number of nests generated was compared with field observations for 1971, 1972, and 1973 (Figure 13). The errors between simulated and observed data for these 3 years were 3.13, 9.92, and 22.70 percent, respectively. Considering possible initial differences in age structure and the unusually large fluctuation in nests over these years, the response of the model seemed reasonably good.

Water Level Fluctuations

In order to test the behavior of the model, several deterministic simulations were run using varied water levels. One such series of 2-year runs is shown in Figure 14. In each of these runs, the water depth in a selected month during the first year was set at either 0 or 30 cm

(1 foot), with water depths for other first year months and all second year months held constant at 15 cm (.5 foot). The difference between the two September runs can be attributed to higher predation, canni-

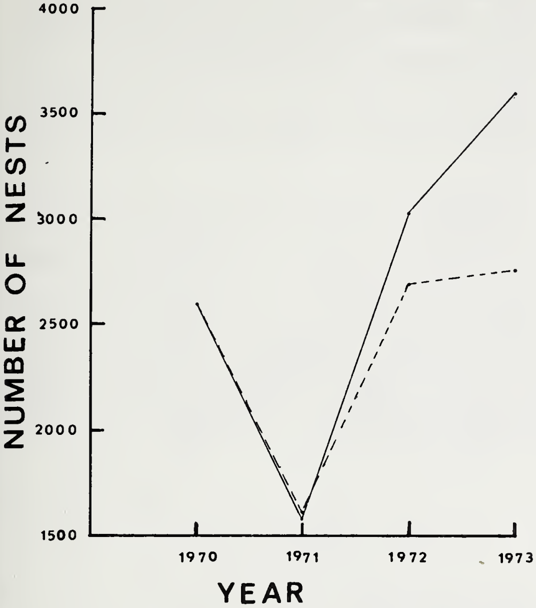

Figure 13.—Comparison of simulated nests (dashed line) with observed nest count data, 1970-1973 (solid line).

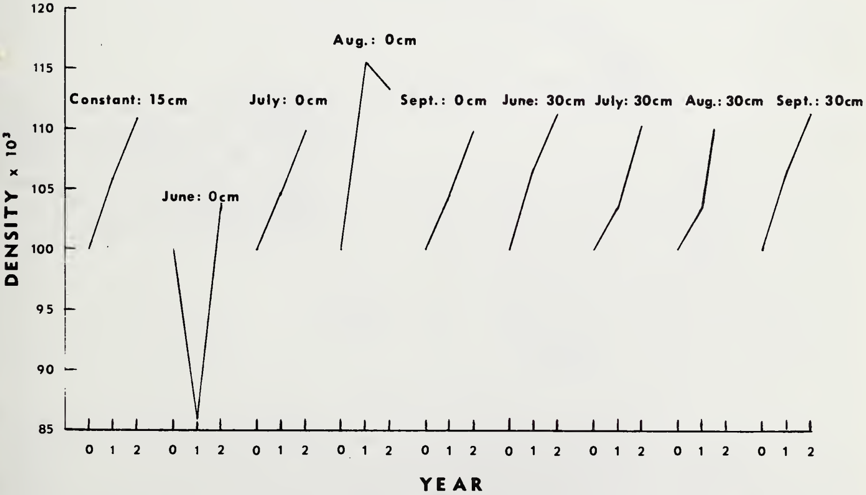

Figure 14.—Series of 2-year simulations demonstrating population response to varied marsh water depths in single selected months. The varied water depths occurred in selected months during the first year, and depths for all other months were held constant at 15 cm (.5 foot).

balism, and desiccation rates in the low water run. Zero water level in June resulted in a substantial population decrease as a consequence of poor nesting effort, although a recovery was made in the following year. Thirty cm (1 foot) water depths in July and August resulted in population declines attributable to nest flooding. Zero water level in August caused a large population increase as a consequence of lowered nest predation and a resultant high number of September hatchlings. Normal predation and increased cannibalism the following year reduced the population, however, primarily by removing large numbers of first year animals.

Population response to hurricane (100 percent nest flooding) and severe drought (increased cannibalism, predation, and desiccation) are shown in Figure 15. The hurricane was simulated with 122 cm (4 feet) water depths in August, and the severe drought was represented by −61 cm (−2 feet) water levels in both June and July. In these 5-year deterministic simulations, the severe weather conditions occurred in year 1, and all water depths were set at 15 cm (.5 foot) for the remainder of each run. The rapid population recoveries from both drought and hurricane were of particular interest.

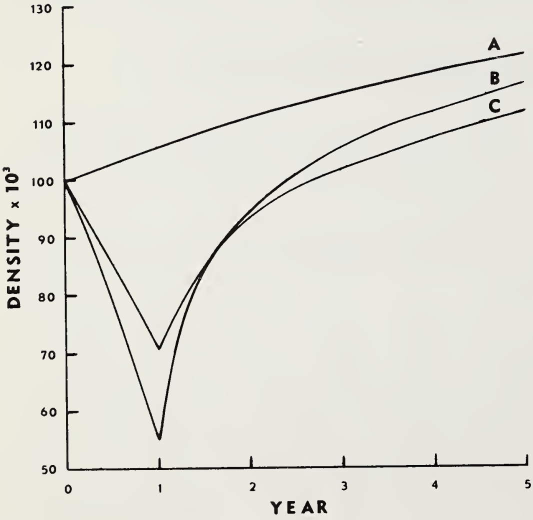

Figure 15.—Simulated population response to August hurricane (plot B) and severe summer drought (plot C). A constant water depth simulation (plot A) is provided for comparison.

The effects of weather were further investigated through the use of environmentally stochastic simulations. In these stochastic runs, monthly water depths were randomly generated from a normal distribution about the mean level for each month (from Table 1). The stochastic modifications also included the .1 probability of a winter freeze each year. Results of two stochastic runs and one deterministic [monthly water levels set at 15 cm (.5 foot), no winter freezes] simulation are shown in Figure 16. It is interesting to note that alligator numbers in the environmentally stochastic simulations exceeded the constant water level population during some years. Age structures generated by the 20-year stochastic runs were extremely irregular and thus seem to preclude the reasonable use of time-specific life table methods in the study of wild alligator populations.

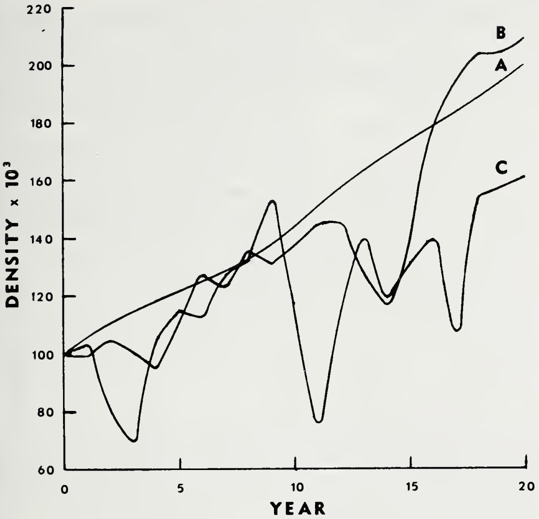

Figure 16.—Simulated population response to constant (plot A) and randomly generated (plots B and C) marsh water depths and winter freezes.

Alligator Harvest Strategies

Differential Harvest Rates

One of the major objectives of this study was to examine the effects of various harvest strategies on alligator populations. This investigation was begun with a series of deterministic simulations [constant water at 15 cm (.5 foot), no freezes] designed to demonstrate population response to various differential hunting rates (Figure 17). Again, these rates applied to animals of harvestable size (aged 4-21 years), rather than to the entire population. Calculations based on these simulations indicated that a harvest rate of approximately 5.28 percent will maintain a base population of 100,000 alligators for at least 20 years. It must be emphasized that the effects of these specific harvest rates on the simulated population should not be generalized to wild alligators. It has been shown that the simulated population does not increase as rapidly as the actual population being modeled (Figure 13), and the real population would thus be expected to tolerate slightly greater harvest rates than the simulated one. The relationships between various harvest rates under different harvest strategies, however, are particularly important.

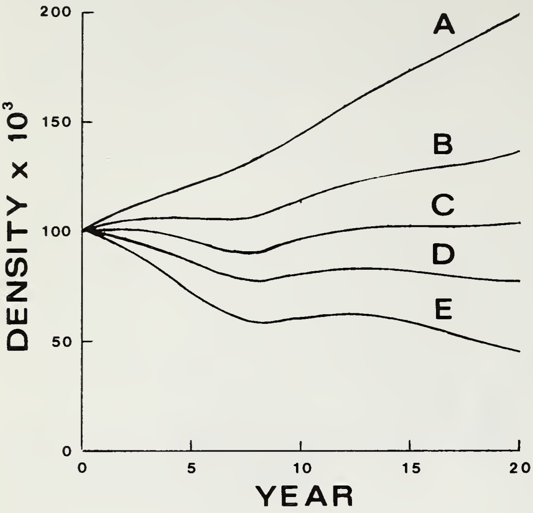

Figure 17.—Simulated population response to various differential harvest rates: plot A = no hunting, plot B = 3 percent, plot C = 5 percent, plot D = 7 percent, plot E = 10 percent. In each simulation water depths were held constant at 15 cm (.5 foot) and no winter freezes occurred.

Another series of deterministic simulations [constant water at 15 cm (.5 foot), no freezes] was run to examine the response of various initial populations to an annual 5 percent hunting rate. The simulations were compared by plotting percent deviation from initial population size versus time (Figure 18). The smaller base populations grew at faster rates than larger populations because of the density dependent effects of

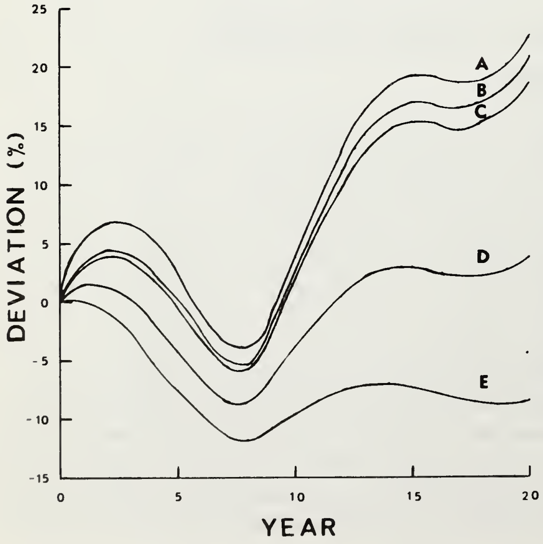

Figure 18.—Simulated response of various initial populations to an annual 5 percent differential harvest rate. Percent deviation from initial population size is plotted for the following initial densities: plot A = 1,000, plot B = 10,000, plot C = 50,000, plot D = 100,000, plot E = 150,000. In each simulation water depths were held constant at 15 cm (.5 foot) and no winter freezes occurred.

cannibalism. It was calculated than an initial population of approximately 115,450 should be maintained for at least 20 years under an annual 5 percent differential hunting regime.

Two stochastic simulations were run to examine the effects of randomly varying water levels and winter temperatures as found in Louisiana on hunted alligator populations. Comparison of these stochastic simulations with a constant water level [15 cm (.5 foot)] simulation (Figure 19) suggested that management strategies should not be based upon assumed average water depths (and thus upon assumed average recruitment and survival rates), but that important environmental parameters should be monitored and considered in the formulation of management plans.

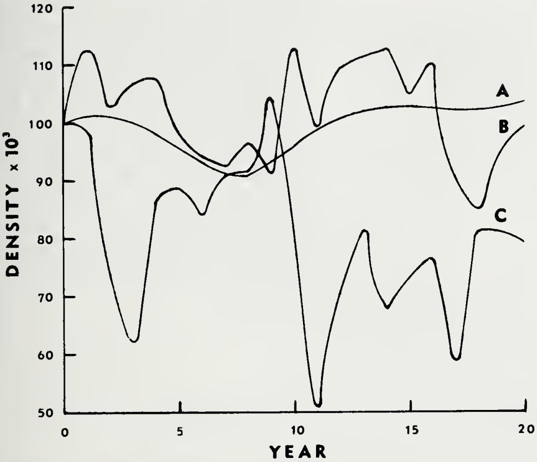

Figure 19.—Simulated population response to an annnual 5 percent differential harvest rate with constant (plot A) and randomly generated (plots B and C) marsh water depths and winter freezes.

A 20-year deterministic simulation with 5 percent differential hunting (Figure 19, plot A) yielded a population which was 48.11 percent smaller than a 20-year non-hunted population (Figure 16, plot A). Simulations of a hunted population (Figure 19, plot C) and a non-hunted population (Figure 16, plot C) were also run using an identical set of randomly generated water levels and winter freezes. In this case, the hunted population was 49.92 percent smaller than the non-hunted population, indicating that hunting may be slightly more detrimental to populations subjected to fluctuating water levels.

Periodic Harvest

Computer simulations of big game populations in which individual female productivity increases with age, suggest that harvests every 2-4 years can increase yields by 10-20 percent (Walters and Bandy 1972). Deterministic simulations were run to evaluate this harvest strategy with respect to alligator populations. These simulations included: (1) harvesting alligators at a 5 percent differential rate every year, (2) harvesting animals at a 10 percent differential rate every second year, and (3) harvesting animals at a 15 percent differential rate every third year (see Figure 20). Valid comparisons of population size under these harvest regimes can be made in years 6, 12, and 18. The periodic harvests did not maintain base populations at the level produced by annual hunting, and did not result in increased yields of alligator hide. Periodic harvesting was thus concluded to be ineffective as a management strategy, possibly because female alligator productivity does not increase with age.

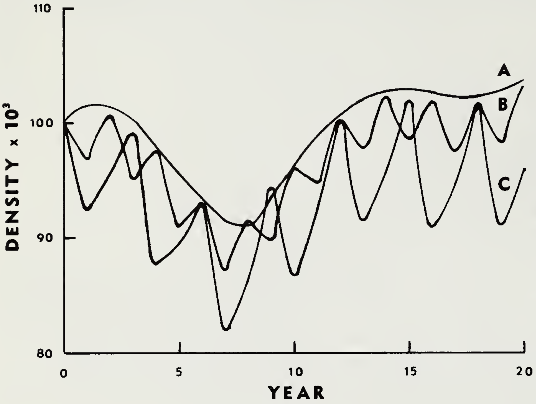

Figure 20.—Simulated population response to periodic harvesting under differential rates. Simulations included harvesting at a 5 percent rate every year (plot A), harvesting at a 10 percent rate every second year (plot B), and harvesting at a 15 percent rate every third year (plot C). In each simulation water depths were held constant at 15 cm (.5 foot) and no winter freezes occurred.

Proportional Harvest Rates

In an attempt to investigate possible means of increasing annual yield, deterministic simulations were run using equal harvest rates for all size classes within a given sex (the 75:25 observed male to female harvest ratio was retained). Such harvest rates are dependent on hunters taking animals in proportion to their relative abundance in the population and will thus be termed "proportional."

The results of 5, 9, 10, and 15 percent proportional hunting rates are presented in Figure 21 and can be compared with differential rates shown in Figure 17. Results of simulations with 5 percent differential and proportional harvest rates are plotted in Figure 22 for direct comparison of effects on population growth. Linear meters and feet of hide taken in selected years at various differential and proportional harvest rates were also calculated (Table 13). The ratio of square feet to linear feet of hide increases with increasing total body length in alligators. Alligator buyers are interested in square feet of hide and thus compensate for this difference by paying higher prices per foot for hide of larger animals. The annual incomes derived from the simulated harvests were thus calculated using two different price schedules, and these values are shown for selected years in Table 14.

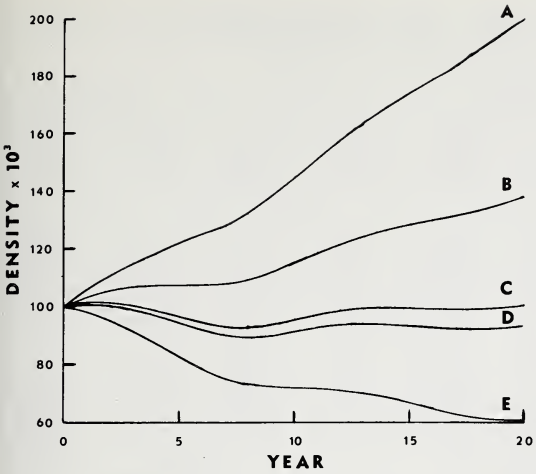

Figure 21.—Simulated population response to various proportional harvest rates: plot A = no hunting, plot B = 5 percent, plot C = 9 percent, plot D = 10 percent, plot E = 15 percent. In each simulation water depths were held constant at 15 cm (.5 foot) and no winter freezes occurred.

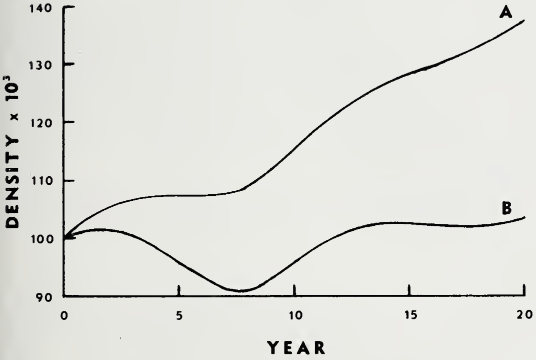

Figure 22.—Simulated population response to annual 5 percent proportional (plot A) and 5 percent differential (plot B) harvest rates. In each simulation water depths were held constant at 15 cm (.5 foot) and no winter freezes occurred.

Table 13.—Yield in hide for selected years under various harvest regimes[a]

	Year		
Harvest regime	1	10	20
	——————Linear meters (feet) of hide——————		
3 percent differential[b]	1,580 (5,185)	1,950 (6,399)	2,298 (7,539)
5 percent differential	2,635 (8,646)	2,845 (9,335)	3,062 (10,045)
7 percent differential	3,693 (12,115)	3,213 (10,542)	3,151 (10,338)
10 percent differential	5,269 (17,288)	3,511 (11,520)	2,910 (9,548)
5 percent proportional[c]	2,328 (7,639)	2,640 (8,663)	3,071 (10,075)
9 percent proportional	4,186 (13,735)	3,862 (12,670)	3,950 (12,960)
10 percent proportional	4654 (15,269)	4,081 (13,389)	4,048 (13,280)
15 percent proportional	6,978 (22,893)	4,717 (15,476)	3,904 (12,809)

[a] Initial population in each case is 100,000.

[b] Population response curves for differential harvest regimes are shown in Figure 17.

[c] Population response curves for proportional harvest regimes are shown in Figure 21.

Table 14.—Derived income from alligator hide sales for selected years under various harvest regimes[a]

	Year 1		Year 10		Year 20	
Harvest regime	Price sched.1[b]	Price sched.2[c]	Price sched.1	Price sched.2	Price sched.1	Price sched.2
	—Dollars—					
3 percent differential[d]	76,575	60,834	94,485	75,078	111,335	88,470
5 percent differential	127,686	101,448	137,803	109,518	148,333	117,858
7 percent differential	178,918	142,158	154,548	123,444	151,735	121,104
10 percent differential	255,316	202,866	168,149	134,748	139,329	111,660
5 percent proportional[e]	111,251	85,206	125,055	95,406	145,485	110,712
9 percent proportional	200,002	153,156	182,081	138,270	186,146	140,814
10 percent proportional	222,369	170,304	192,233	145,782	190,581	143,934
15 percent proportional	333,379	255,312	221,154	166,524	182,821	136,878

[a] Initial alligator population in each case was 100,000. Corresponding harvest yields expressed in linear meters and feet of hide are shown in Table 13.

[b] Price schedule 1 corresponds to prices paid for alligators taken during the 1973 harvest season. Prices were $14.00 per foot for 4, 5, and 6 feet alligators, $15.00 per foot for 7 and 8 feet alligators, and $16.00 per foot for animals 9 feet and larger (Mirandona Brothers pers. comm.).

[c] Price schedule 2 corresponds to predicted future hide prices. Predicted prices are $7.50 per foot for 4 feet alligators and $12.00 per foot for animals 5 feet and larger (Mirandona Brothers pers. comm.).

[d] Population response curves for differential harvest regimes are shown in Figure 17.

[e] Population response curves for proportional harvest regimes are shown in Figure 21.

The proportional harvest strategy appeared to be highly successful, and, with respect to population growth, a 9 percent proportional rate was virtually equivalent to a 5 percent differential rate. The 9 percent proportional rate, however, yielded a much greater amount of hide and resulting income than the 5 percent differential rate (Tables 13 and 14). It thus appears that alligator populations can withstand a much higher rate of proportional than differential hunting, and that higher proportional rates can result in increased yield of hide.

Taking different sized animals in proportion to their abundance in the population is a management strategy which should be relatively easy to implement. In 1972, alligators taken by shooting were generally in the smaller size classes (Palmisano *et al.* 1973), probably because of the larger number of small animals in the hunted population. Fishing with a baited line, however, appeared to catch the larger animals, and this resulted in part from the intentional placement of baited hooks high above the water surface (Palmisano *et al.* 1973). Regulations could be imposed to lower the heights of alligator hooks above the water, thus giving animals of various sizes an equal opportunity to strike. Also, shooting or live-trapping, as described by Chabreck (1963), could be employed, thus enabling hunters to select certain size classes.

Egg Collection Management

Collecting and artifically incubating eggs, distributing hatchlings, and rearing young animals has been reported to be a successful management strategy for crocodiles (*Crocodylus niloticus* Laurenti) in South Africa (Pooley 1969, 1971) and Rhodesia (Blake 1970). This type of management program was examined for alligators through the use of deterministic and stochastic simulations. In the simulations, 10,000 eggs were "collected" in early July each year, and the young alligators were released in September after either one or two years of rearing. A 75 percent hatching rate was assumed for the artificially incubated eggs (Chabreck unpubl. data), and first and second year annual mortality rates for reared young were assumed to be 10 and 5 percent, respectively. Pen-reared alligators respond similarly to wild alligators when transferred to new locations and released (Chabreck 1971a). In the model, pen-reared alligators which were reintroduced to the population were thus assumed to be qualitatively similar to wild alligators of the same age.

Collecting eggs and rearing and releasing young alligators appears to be a very effective management strategy as indicated by deterministic simulations (Figure 23). After 20 years, the 1- and 2-year rearing programs resulted in populations which were 20.37 and 38.23 percent, respectively, larger than the unmanaged population. The managed populations began to diverge rapidly from the unmanaged population during year 9, the year in which the first group of artificially raised females reached sexual maturity.

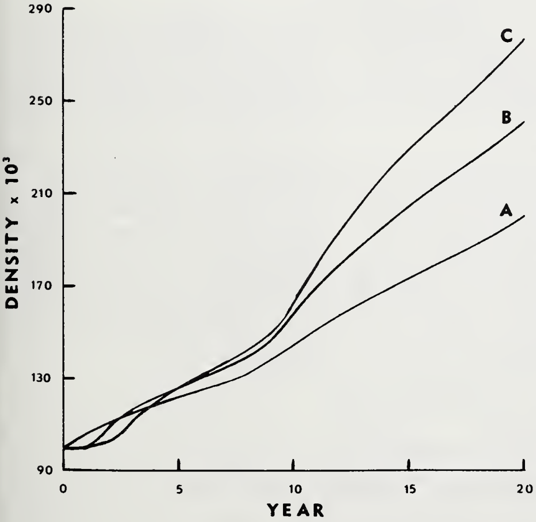

Figure 23.—Simulated population response to egg collection management programs. Plot A corresponds to no management. Plot B corresponds to a management program in which 10,000 eggs were collected annually, and hatchlings were reared for 1 year and released. Plot C corresponds to a management program in which 10,000 eggs were collected annually, and hatchlings were reared for 2 years and released. In each simulation water depths were held constant at 15 cm (.5 foot) and no winter freezes occurred.

An egg collection management program with one year of rearing young was also simulated using the same set of randomly generated water levels and winter freezes used for the unmanaged population shown in Figure 16, plot C. Under this particular set of environmental conditions, the managed population was 26.32 percent larger than the unmanaged population at the end of 20 years. This difference between managed and unmanaged populations was considerably larger than the difference (20.37 percent) indicated by the deterministic simulations. Thus, it appears that the beneficial effects of an egg collection management program are increased during periods of wide water level fluctuations. This conclusion was expected, since egg collection management results in the protection of eggs and first year animals, which suffer the greatest increases in mortality during periods of changing water levels.

Simulation can be used in the economic analysis of possible management options. For example, simulations indicated that the addition of an egg collection management program (one year of rearing young) to a 7 percent differential harvest regime resulted in maintenance of the base population after a period of 20 years, while a similarly hunted but unmanaged population decreased considerably (Figure 24). The numbers of linear meters and feet of hide harvested each year under a 7 percent differential harvest regime with and without egg collection management were calculated and are presented in Table 15. The egg collection management program resulted in a total increase in yield of 13,629 meters (44,713 feet) of hide over the unmanaged population. Using an average 1973 price of $13.13 per linear foot (Joanen *et al.* 1973), the increased yield results in a total difference of approximately $587,100. This increased revenue reduces to approximately $29,400 per year.

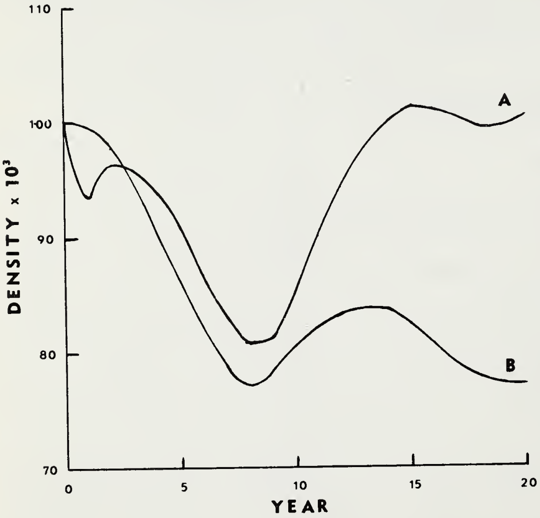

Figure 24.—Simulated population response to an annual 7 percent differential harvest rate with and without egg collection management. Plot A corresponds to a management program in which 10,000 eggs were collected annually, and hatchlings were reared for 1 year and released. Plot B corresponds to no egg collection management. In each simulation water depths were held constant at 15 cm (.5 foot) and no freezes occurred.

Table 15.—Yield in hide from 7 percent differentially harvested alligator populations with and without an egg collection management program[abc]

Year	Egg collection management	No management
	— — — — — —Linear meters (feet) of hide— — — — — —	
1	3,693 (12,115)	3,693 (12,115)
2	3,597 (11,801)	3,590 (11,779)
3	3,629 (11,907)	3,626 (11,897)
4	3,841 (12,602)	3,836 (12,585)
5	4,235 (13,894)	3,918 (12,854)
6	4,453 (14,609)	3,918 (12,854)
7	4,435 (14,549)	3,815 (12,515)
8	4,178 (13,708)	3,564 (11,693)
9	4,045 (13,272)	3,343 (10,968)
10	3,942 (12,934)	3,213 (10,542)
11	3,857 (12,653)	3,144 (10,316)
12	3,874 (12,710)	3,107 (10,193)
13	3,951 (12,962)	3,105 (10,188)
14	4,015 (13,174)	3,170 (10,399)
15	4,157 (13,640)	3,307 (10,851)
16	4,388 (14,396)	3,352 (10,998)
17	4,512 (14,802)	3,354 (11,005)
18	4,571 (14,998)	3,328 (10,919)
19	4,592 (15,067)	3,282 (10,768)
20	4,480 (14,697)	3,151 (10,338)
Total	82,445 (270,490)	68,817 (225,777)

[a] Initial population in each case is 100,000.

[b] Population response curves are shown in Figure 24.

[c] Egg collection management program included collecting and hatching 10,000 eggs annually and rearing young for one year before reintroduction.

The cost of an egg collection management program would probably prohibit such an operation if it was conducted on a strictly economic basis. The cost of rearing 7,500 alligators to age 1 would be about $38,000. The estimated cost of major expenditures would be: food, including vitamin and mineral supplements, $5,000 (Coulson *et al.* 1973); labor, $18,000; equipment and supplies, $10,000; facilities, depreciated over a 20-year period, $5,000. An egg collection program would thus not be economically justifiable in the situation described. However, similar economic analyses can be applied to a wide variety of situations involving different harvest and management options, and the above example was simply provided to demonstrate the utility of simulation for such analyses.

SUMMARY AND CONCLUSIONS

A model was constructed to simulate the dynamics of the alligator population inhabiting the privately owned marshland of Cameron and Vermilion parishes, Louisiana. The model was used to examine the consequences of various management strategies and the effects of variable environmental parameters on the alligator population.

Data used to construct the model were assembled from a variety of published and unpublished sources. In some cases, it was necessary to rely upon estimates based on field observations of wild alligators in the study area. The general approach to the model was to sacrifice statistical rigor, when necessary, in order to obtain a reasonably complete model. As a result, the model is believed to include most of the relationships affecting the studied alligator population, although knowledge of the exact nature of some of the included functions will require further field research.

During the construction of the model, it became evident that numerous important phases of alligator population biology have been either inadequately studied or completely neglected. We, therefore, recommend that additional research effort be expended on the following functional relationships affecting alligators: (1) growth rates of wild alligators and effects of food intake and temperature on these rates; (2) the relationship between the percentage of female alligators nesting and marsh water depth; (3) the relationship between nest flooding rates and marsh water depth; (4) the interrelationship between nest predation, raccoon density, and marsh water depth; (5) the effects of population density and marsh water depth on cannibalism rate; (6) the effects of predator density and marsh water depth on predation rates of young alligators; and (7) the relationship between desiccation mortality and marsh water depth. Obviously, this is not an exhaustive list of possible alligator research topics, but it does include the relationships which appeared to be of primary importance to the studied population.

In the model, nesting effort, nest flooding, desiccation mortality, and predation on alligator eggs and young were all determined as functions of monthly water depth averages. Cannibalism was considered to be the major density dependent factor operating on the population and was determined as a function of total population density and marsh water depth. The model contained a freeze mortality which was based on minimum winter temperatures. In addition, the model included a harvest option which resulted in alligator hunting mortality.

A mechanistic mathematical model was constructed to simulate the behavior of the population over time. The modeled system was defined as the alligator population existing in the study area and was divided into components according to age and sex. In the model, animals were grouped in a matrix fashion, with each element corresponding to a population component. The structure of the model incorporated the use of state equations which described the behavior of each component in terms of stimulus and response variables. State variables were defined as the number of animals in each age and sex class. The model was basically deterministic but included an optional stochastic modification which produced random monthly water depths and winter temperatures.

The model was tested by means of a simulation with observed 1970-1973 monthly marsh water depths. Alligator nest counts were conducted in the study area during these years, and the numbers of nests produced by the simulated population were compared with these field observations. The errors between simulated and observed data for the years 1971-1973 were 3.13, 9.92, and 22.70 percent, respectively.

The behavior of the model was tested using deterministic simulations with various water depth inputs for selected months. Zero water level in June produced an especially significant result, causing a substantial population decrease attributable to poor nesting effort and a resultant small number of hatchlings. Simulations of an August hurricane and a summer drought each produced substantial population declines, although rapid recoveries occurred in both cases. Environmentally stochastic simulations produced extremely irregular population response curves with high year-to-year variation in density. Age structures generated by the stochastic simulations were also irregular and seemed to preclude the reasonable use of time-specific life table methods on the studied alligator population.

Deterministic simulations using various differential hunting rates indicated that a base population of 100,000 alligators should be maintained for 20 years when subjected to an annual hunting rate slightly greater than 5 percent. Deterministic simulations also indicated that small base populations can withstand greater hunting rates than larger populations because of the density dependent effects of cannibalism. Environmentally stochastic simulations indicated that harvest strategies should not be based on assumed average recruitment and survival rates, but that important environmental parameters should be monitored and considered in the formulation of management plans.

Deterministic simulations indicated that periodic harvesting is an ineffective management strategy for the simulated alligator population. Experimental simulations were run using equal harvest rates for all size classes within a given sex (proportional hunting). Comparisons of population response curves for simulations with equivalent differential and proportional hunting rates indicated that much greater population increases are possible with proportional hunting. Nine percent proportional hunting and 5 percent differential hunting produced similar population response curves, although the 9 percent proportional hunting yielded a greater amount of alligator hide. The proportional harvest strategy thus appeared to be highly successful, and recommendations were made for implementation of such a strategy.

Deterministic simulations with egg collection management programs produced greater population increases than similar simulations with no management. Stochastic simulations indicated that the beneficial effects of egg collection management are enhanced during periods of wide water level fluctuations. An example was provided to demonstrate the use of simulation in the economic analysis of management options. In the example used, it appeared that an annual egg collection management program was not justifiable on a strictly economic basis.

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APPENDIX

Computer Program Used for Simulations

```
      PROGRAM GATRAID(INPUT,OUTPUT,TAPE60=INPUT,TAPE61=OUTPUT)
      REAL NESTEFF,NESTFLD,NATURAL(21,2),KILL
      INTEGER TEMP
      DIMENSION AGEINIT(21,2),HUNTING(14),REPROD(14),FLDLOSS(6),WATER(12
     1),DUMMY(21,2),SEX(2),WLEVEL(12,2),HARNUM(14),TOTSIZE(14),SURHUNM(2
     21,2),DESS1(15),DESS2(13),DESS3(9)
      DIMENSION IHARNUM(14),IFT(9)
      COMMON SURNATM,SURHUNM,NESTEFF,REPRATE,NESTFLD,EGGS,NYR
      COMMON APRED,CANN,CANNMUL,CANNAB,DESS
      COMMON AGEINIT,TEMP,HUNRATE,MONTH,HACHTOT,PRED
      DATA WLEVEL/1.0,1.1,5*0.,.6,.9,.8,.4,.8,.39,.36,5*0.,.17,.44,.28,.
     129,.28/
      DATA SEX/5RMALE ,7RFEMALE /
      DATA WATER/12*.5/
      DATA NO/1RN/
      DATA REPROD/.335,.345,.355,.365,.38,.405,.45,.5,.56,.6,.63,.645,.6
     155,.67/
      DATA FLDLOSS/.03,.055,.08,.295,.515,.725/
      DATA NATURAL/.011,.044,.031,5*.033,13*.043,.011,.044,.031,5*.033,
     113*.02/
      DATA HUNTING/5.93,13.68,14.34,12.99,9.14,6.36,4.64,2.49,.53,3.77,6
     1.87,10.30,7.03,1.93/
      DATA DESS1/.0,.001,.003,.005,.007,.009,.012,.016,.022,.030,.041,.0
     161,.088,.120,.135/
      DATA DESS2/.0,.001,.002,.003,.006,.011,.017,.027,.043,.064,.082,.0
     194,.102/
      DATA DESS3/.0,.001,.002,.003,.006,.013,.023,.033,.037/
      READ(60,900)NUMYRS,AGEINIT
      PRINT 951
      WRITE(61,950)((AGEINIT(I,J),J=1,2),I=1,21)
      READ(60,911) HUNRATE,IDIFF
  911 FORMAT(F5.2,I2)
      XX=3379.
      CALL RANSET(XX)
      TOTS1=0.0   $   TOTS2=0.0   $   IGRTOT=0
      DO 1000 NYR=1,NUMYRS
      MN=0
      EGGS=0.
      MONTH=0
*************INPUTS TO SYSTEM ARE WATER, DESIRED HARVEST, FREEZE OPTION
              FREEZE OPTION IS ONLY INPUT FOR WINTER MONTHS
    5 MONTH=MONTH+1
      HUNSURV=1.0
      TOTAL=0.
      DO 1500 I=1,21
      TOTAL=TOTAL+AGEINIT(I,1)
 1500 TOTAL=TOTAL+AGEINIT(I,2)
      IF(MONTH.EQ.3)GO TO 10
      MN=MN+1
      WATER(MN)=FXLEVEL(WLEVEL,MN)
      IF(MONTH.NE.1)GO TO 9
      IF(HUNRATE.EQ.0)GO TO 9
      REPFEM=0.0
      HARFEM=0.0
      HARMAL=0.0
      HARTOT=0.
      DO 1700  I=9,21
 1700 REPFEM=REPFEM+AGEINIT(I,2)
      DO 1501 I=4,21
      HARMAL=HARMAL+AGEINIT(I,1)
      HARFEM=HARFEM+AGEINIT(I,2)
 1501 HARTOT=HARMAL+HARFEM
      WRITE(61,903)HARTOT
  903 FORMAT(2X,*TOT HARVESTABLE = *,F10.0)
      WRITE(61,1750) HARFEM
 1750 FORMAT(*+*,35X,*TOT HARVESTABLE FEMS =*,F10.0)
      WRITE(61,1751) REPFEM
 1751 FORMAT(*+*,75X,*TOT REPRODUCTIVE FEMS =*,F10.0)
      HARTOT=.01*HUNRATE*HARTOT
      WRITE(61,904)HARTOT
  904 FORMAT(2X,*AFTER PERC TAKEN *,F10.0)
      TOTSIZE(1)=AGEINIT(4,1)
      TOTSIZE(2)=AGEINIT(5,1)+AGEINIT(6,1)
      TOTSIZE(3)=AGEINIT(7,1)
      TOTSIZE(4)=AGEINIT(8,1)
      J=9
      DO 1503 I=5,8
      TOTSIZE(I)=AGEINIT(J,1)+AGEINIT(J+1,1)
```

(Continued)

Computer Program Used for Simulations (continued)

```
1503 J=J+2
     TOTSIZE(9)=AGEINIT(17,1)+AGEINIT(18,1)+AGEINIT(19,1)+AGEINIT(20,1
    1+AGEINIT(21,1)
     TOTSIZE(10)=AGEINIT(4,2)+AGEINIT(5,2)
     TOTSIZE(11)=AGEINIT(6,2)+AGEINIT(7,2)+AGEINIT(8,2)
     TOTSIZE(12)=AGEINIT(9,2)+AGEINIT(10,2)+AGEINIT(11,2)
     TOTSIZE(13)=AGEINIT(12,2)+AGEINIT(13,2)+AGEINIT(14,2)
     TOTSIZE(14)=0.
     DO 1504 I=15,21
1504 TOTSIZE(14)=TOTSIZE(14)+AGEINIT(I,2)
     WRITE(61,954)TOTSIZE
 954 FORMAT(2X,*TOTSIZE*,2(/,7F9.0))
     IF(IDIFF.EQ.1)  GO TO 1800
     TOTMALH=.70*HARTOT
     TOTFEMH=.30*HARTOT
     RATEMAL=TOTMALH/HARMAL
     RATEFEM=TOTFEMH/HARFEM
     DO 1810  I=1,9
1810 HARNUM(I)=RATEMAL*TOTSIZE(I)
     DO 1820  I=10,14
1820 HARNUM(I)=RATEFEM*TOTSIZE(I)
     GO TO 1850
1800 DO 1502  I=1,14
1502 HARNUM(I)=.01*HUNTING(I)*HARTOT
1850 DO 960  I=1,14
 960 IF(HARNUM(I).GT.TOTSIZE(I))  HARNUM(I)=TOTSIZE(I)
     WRITE(61,955)HARNUM
 955 FORMAT(2X,*HARNUM*,2(/,7F9.0))
     DO 1840  I=1,14
1840 IHARNUM(I)=HARNUM(I) + .5
     DO 1841  I=1,9
1841 IFT(I)=0
     DO 1843  I=1,9
1843 IFT(I)=IHARNUM(I)*(3+I)
     DO 1845  I=1,5
1845 IFT(I)=IFT(I)+(IHARNUM(I+9)*(3+I))
     WRITE(61,998) IFT
 998 FORMAT(*  IFT*,9I6)
     ITOTFT=0
     DO 1855  I=1,9
1855 ITOTFT=ITOTFT+IFT(I)
     IGRTOT=IGRTOT+ ITOTFT
     SCHED2=0.0   $   SCHED1=0.0
     SCHED2=7.5*IFT(1)
     DO 1860  I=2,9
1860 SCHED2=SCHED2+(IFT(I)*12.0)
     DO 1865  I=1,3
1865 SCHED1=SCHED1+(IFT(I)*14.0)
     DO 1869  I=4,5
1869 SCHED1=SCHED1+(IFT(I)*15.0)
     DO 1870  I=6,9
1870 SCHED1=SCHED1+(IFT(I)*16.0)
     TOTS1=TOTS1+SCHED1
     TOTS2=TOTS2+SCHED2
     DO 1511 I=1,14
     IF(TOTSIZE(I).NE.0.)GO TO 1511
     TOTSIZE(I)=1.
     HARNUM(I)=1.
1511 CONTINUE
     DO 1505 I=1,3
     SURHUNM(I,1)=1.
1505 SURHUNM(I,2)=1.
     SURHUNM(4,1)=(TOTSIZE(1)-HARNUM(1))/TOTSIZE(1)
     SURHUNM(5,1)=(TOTSIZE(2)-HARNUM(2))/TOTSIZE(2)
     SURHUNM(6,1)=SURHUNM(5,1)
     SURHUNM(7,1)=(TOTSIZE(3)-HARNUM(3))/TOTSIZE(3)
     SURHUNM(8,1)=(TOTSIZE(4)-HARNUM(4))/TOTSIZE(4)
     J=4
     DO 1506 I=9,15,2
     J=J+1
     SURHUNM(I,1)=(TOTSIZE(J)-HARNUM(J))/TOTSIZE(J)
1506 SURHUNM(I+1,1)=SURHUNM(I,1)
     DO 1507 I=17,21
1507 SURHUNM(I,1)=(TOTSIZE(9)-HARNUM(9))/TOTSIZE(9)
     SURHUNM(4,2)=(TOTSIZE(10)-HARNUM(10))/TOTSIZE(10)
     SURHUNM(5,2)=SURHUNM(4,2)
     J=11
     DO 1508 I=6,12,3

     SURHUNM(I,2)=(TOTSIZE(J)-HARNUM(J))/TOTSIZE(J)
     SURHUNM(I+1,2)=SURHUNM(I+2,2)=SURHUNM(I,2)
1508 J=J+1
     DO 1509 I=15,21
```

(Continued)

Computer Program Used for Simulations (continued)

```
1509 SURHUNM(I,2)=(TOTSIZE(14)-HARNUM(14))/TOTSIZE(14)
     DO 1510 I=4,21
     IF(SURHUNM(I,1).LT.0.)SURHUNM(I,1)=0.
     IF(SURHUNM(I,2).LT.0.)SURHUNM(I,2)=0.
1510 CONTINUE
     WRITE(61,953)SURHUNM
 953 FORMAT(2X,*HUNTING SURV RATES*,2(/,5X,21F5.3))
     WRITE(61,1880) ITOTFT,SCHED1,SCHED2
1880 FORMAT(*  TOTAL FT HARVESTED=*,I12,5X,*SCHED1 YIELD = $*,F15.2,5X,
    1*SCHED2 YIELD = $*,F15.2)
     IF(NUMYRS-NYR) 1898,1881,1898
1881 WRITE(61,1882) IGRTOT,TOTS1,TOTS2
1882 FORMAT(*  GRAND TOTAL FT=*,I12,* GRAND TOTAL SCHED1 =*,F15.2,* GRA
    1ND TOTAL SCHED2 =*,F15.2)
1898 CONTINUE
   9 CANNMUL=-1.46*WATER(MN)+1.73
     IF(WATER(MN).GE.1.01)CANNMUL=.25
     GO TO 15
  10 TEMP=1RN
     T=RANF(0)
     IF(T.LE..1)TEMP=1RY
     MN=7
     MONTH=7
**************THIS SEGMENT COMPUTES PREDATION AND DESICCATION RATES TO BE
               ADDED TO NATURAL MORTALITY RATES GIVING TOTAL SURVIVORSHIP
               RATES FOR EACH AGE AND SEX CLASS
  15 DO 1200 ISEX=1,2
     DO 1300 ICLASS=1,21
     APRED=0.
     CANN=0.
     DESS=0.
     IF(MONTH.NE.7)GO TO 16
     IF(TEMP.EQ.NO)GO TO 1302
     SURNATM=.95
     GO TO 55
  16 IF(ICLASS.NE.1)GO TO 20
     CANN=.00000021*TOTAL-.0071
     IF(TOTAL.LE.38600.)CANN=.001
     IF(WATER(MN).GT.3.46)GO TO 25
     APRED=-.0236*WATER(MN)+.1318
     IF(WATER(MN).GT.-.8) GO TO 200
     IF(WATER(MN).LT.-2.2) WATER(MN)=-2.2
     I=10.*ABS(WATER(MN))-7.
     DESS=DESS1(I)
     GO TO 201
 200 DESS=0.0
 201 CONTINUE
     GO TO 30
  25 APRED=.05
     GO TO 30
  20 IF(ICLASS.NE.2)GO TO 35
     CANN=.00000016*TOTAL-.0055
     IF(TOTAL.LE.40600.)CANN=.001
     IF(WATER(MN).GT..91)GO TO 40
     APRED=-.024*WATER(MN)+.032
     IF(WATER(MN).GT.-1.0) GO TO 210
     IF(WATER(MN).LT.-2.2) WATER(MN)=-2.2
     I=10.*ABS(WATER(MN))-9.
     DESS=DESS2(I)
     GO TO 211
 210 DESS=0.0
 211 CONTINUE
     GO TO 30
  40 APRED=.01
     GO TO 30
  35 IF(ICLASS.NE.3)GO TO 44
     CANN=.00000005*TOTAL-.0016
     IF(TOTAL.LE.52000.)CANN=.001
  44 IF(ICLASS.GT.2.AND.ISEX.EQ.2.OR.ICLASS.GT.2.AND.ICLASS.LT.7.AND.IS
    1EX.EQ.1)GO TO 45
     GO TO 30
  45 IF(WATER(MN).GT.-1.4) GO TO 220
     IF(WATER(MN).LT.-2.2) WATER(MN)=-2.2
     I=10.*ABS(WATER(MN))-13.
     DESS=DESS3(I)
     GO TO 221
 220 DESS=0.0
 221 CONTINUE
C**************APPLY SURVIVORSHIP DUE TO HUNTING DURING SEPTEMBER
  30 IF(MONTH.NE.1)GO TO 31
     IF(HUNRATE.EQ.0)GO TO 31
     HUNSURV=SURHUNM(ICLASS,ISEX)
  31 CANNAB=CANNMUL*CANN
     SURNATM=1-(APRED+CANNAB+DESS+NATURAL(ICLASS,ISEX))
```

(Continued)

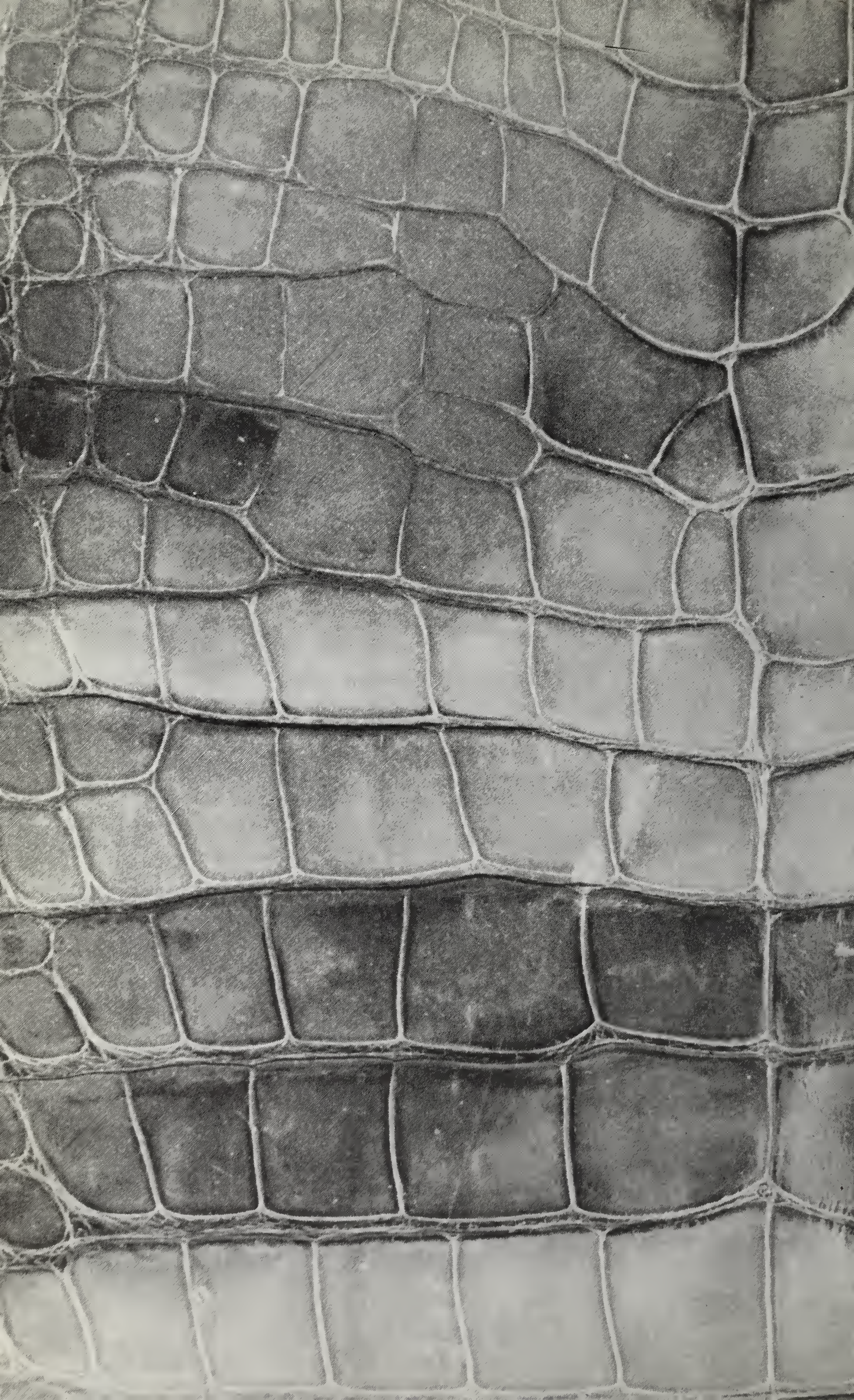
Computer Program Used for Simulations (continued)

```
C**************UPDATE AGE STRUCTURE
   55 AGEINIT(ICLASS,ISEX)=AGEINIT(ICLASS,ISEX)*SURNATM*HUNSURV
      IF(ISEX.EQ.2.AND.MONTH.EQ.10.AND.ICLASS.GT.8)GO TO 60
      GO TO 1301
C**************THIS SEGMENT COMPUTES PERCENTAGE OF FEMALES WHICH NEST AND
C               TOTAL EGGS LAID
   60 AVG=(WATER(9)+WATER(10))/2.
      IF(AVG.LT..05)AVG=0.
      IF(AVG.GE..65)AVG=.67
      I=20.*AVG+1.
      NESTEFF=REPROD(I)
      REPRATE=NESTEFF*AGEINIT(ICLASS,ISEX)
      EGGS=EGGS+REPRATE*38.9
 1301 CALL SBPRINT(-1,WATER,ISEX,ICLASS)
 1300 CONTINUE
 1200 CONTINUE
 1302 CONTINUE
      IF(MONTH.NE.12)GO TO 5
      I=10
C**************THIS SEGMENT COMPUTES PERCENTAGE OF EGGS LOST DUE TO FLOODI
      IF(WATER(10)-WATER(11))65,70,70
   65 IF(WATER(11).LT.WATER(12))GO TO 75
      I=11
      GO TO 80
   70 IF(WATER(10)-WATER(12))75,80,80
   75 I=12
   80 IF(WATER(I).LT..9)GO TO 85
      IF(WATER(I).GE.1.5.AND.WATER(I).LT.4.)GO TO 90
      IF(WATER(I).GE.4.)GO TO 95
      GO TO 100
   85 NESTFLD=0.
      GO TO 105
   90 NESTFLD=.933
      GO TO 105
   95 NESTFLD=1.
      GO TO 105
  100 J=10.*WATER(I)-8.
      NESTFLD=FLDLOSS(J)
C**************THIS SEGMENT COMPUTES PERCENTAGE OF EGGS LOST DUE TO PREDAT
  105 PRED=.035
      IF(WATER(12).LT..2.OR.WATER(12).GT.1.2)GO TO 110
      IF(WATER(12).GE..2.AND.WATER(12).LE..8)GO TO 115
      PRED=-.825*WATER(12)+1.025
      GO TO 110
  115 PRED=.55*WATER(12)-.075
  110 HACHTOT=(EGGS*(1.-NESTFLD))*(1.-PRED)*.768
C**************MOVE ALL AGE CLASSES UP INTO NEXT YEAR CLASS
      DO 1400 I=1,20
      DUMMY(I+1,1)=AGEINIT(I,1)
 1400 DUMMY(I+1,2)=AGEINIT(I,2)
      DO 1401 I=2,21
      AGEINIT(I,1)=DUMMY(I,1)
 1401 AGEINIT(I,2)=DUMMY(I,2)
C**************COMPUTE NEW ZERO YEAR CLASS
      AGEINIT(1,1)=HACHTOT*.601
      AGEINIT(1,2)=HACHTOT*.399
      CALL SBPRINT(1,WATER,ISEX,ICLASS)
      TOTAL = 0.0
      DO 1910  J=1,2
      DO 1910  I=1,21
 1910 TOTAL=TOTAL+AGEINIT(I,J)
      IF(NYR.EQ.1)  OLDTOT=100000.
      IF(NYR.EQ.1)  TOTLAM=1.0
      XLAMBDA=TOTAL/OLDTOT
      TOTLAM=TOTLAM*XLAMBDA
      OLDTOT=TOTAL
      WRITE(61,1903) XLAMBDA
 1903 FORMAT(*+*,55X,*LAMBDA=*,F10.6)
      IF(NUMYRS-NYR) 1908,1904,1908
 1904 XNUMYRS=NUMYRS
      XMEAN=TOTLAM**(1./XNUMYRS)
      WRITE(61,1905) XMEAN
 1905 FORMAT(*+*,80X,*MEAN LAMBDA=*,F10.6)
 1908 CONTINUE
 1000 CONTINUE
  900 FORMAT(I2,3(/,14F5.0))
  901 FORMAT(F5.2)
  950 FORMAT(41X,*MALES*,10X,*FEMALES*,//,21(37X,F9.0,7X,F9.0,/))
  951 FORMAT(*0*,10X,*INITIAL AGE STRUCTURE*)
  952 FORMAT(10X,*NUMBER OF *,R7,*HARVESTED FROM *,I2,* AGE CLASS =*,F9.
     10)
      END
```

(Continued)

Computer Program Used for Simulations (continued)

```
      FUNCTION FXLEVEL(WLEVEL,MONTH)
      DIMENSION WLEVEL (12,2)
      SUM=0.
      DO 100 I=1,12
100   SUM=SUM+RANF(0)
      FXLEVEL=(SUM-6.)*WLEVEL(MONTH,2)+WLEVEL(MONTH,1)
      RETURN
      END
      SUBROUTINE SBPRINT(JBUG,WATER,ISEX,ICLASS)
      REAL NESTEFF,NESTFLD
      INTEGER TEMP,YES
      DIMENSION MONTHS(12),WATER(12)
      DIMENSION SEX(2)
      COMMON SURNATM,SURHUNM(21,2),NESTEFF,REPRATE,NESTFLD,EGGS,NYR
      COMMON APRED,CANN,CANNMUL,CANNAB,DESS
      COMMON AGEINIT(21,2),TEMP,HUNRATE,MONTH,HACHTOT,PRED
      DATA SEX/5RMALE ,7RFEMALE /
      DATA MONTHS/9HSEPTEMBER,7HOCTOBER,0,0,0,0,6HWINTER,5HAPRIL,3HMAY,4
     1HJUNE,4HJULY,6HAUGUST/
      DATA YES/1RY/
      IF(JBUG.LT.0)RETURN
      IF(JBUG)4,9,9
    4 IF(MONTH.EQ.1)GO TO 5
      RETURN
    5 WRITE(61,101)ISEX,ICLASS,MONTHS(MONTH)
      WRITE(61,100)CANNMUL,CANN,CANNAB,APRED,SURNATM,SURHUNM(ICLASS,ISEX
     1),DESS
      IF(MONTH.EQ.10.AND.ISEX.EQ.2.AND.ICLASS.GT.8)GO TO 11
      RETURN
   11 WRITE(61,108)NESTEFF,REPRATE,EGGS
      RETURN
    9 WRITE(61,113)NYR
      WRITE(61,102)MONTHS(MONTH)
      IF(MONTH.EQ.1)WRITE(61,103)HUNRATE
      IF(MONTH.EQ.7)GO TO 15
      WRITE(61,111)WATER(MONTH)
      GO TO 20
   15 IF(TEMP-YES)25,30,25
   25 PRINT 104
      GO TO 20
   30 PRINT 105
   20 IF(JBUG.NE.1)GO TO 32
      PERCN=100.*NESTEFF
      WRITE(61,112)PERCN,EGGS
      PERCN=100.*NESTFLD
      PERCP=100.*PRED
      WRITE(61,110)PERCN,PERCP
      WRITE(61,109)HACHTOT,AGEINIT(1,1),AGEINIT(1,2)
   35 PRINT 106
      DO 31 I=1,21
   31 WRITE(61,107)I,AGEINIT(I,1),AGEINIT(I,2)
   32 TOTAL=0.
      DO 1500 J=1,2
      SUM=0.
      DO 1501 I=1,21
 1501 SUM=SUM+AGEINIT(I,J)
      WRITE(61,902)SEX(J),SUM
 1500 TOTAL=TOTAL+SUM
      WRITE(61,903)TOTAL
      RETURN
  101 FORMAT(2X,*SEX =*,I2,2X,*CLASS =*,I3,A10)
  902 FORMAT(16X,R10,*POPULATION = *,F12.0)
  903 FORMAT(20X,*TOTAL POPULATION = *,F12.0)
  113 FORMAT(1X,10H**********,*YEAR *,I2)
  100 FORMAT(2X,*CANNMUL=*,F4.2,*CANN=*,F4.2,*CANNAB=*,F4.2,*APRED=*,F4.
     12,*SURNATM=*,F4.2,*SURHUNM=*,F4.2,1X,*DESS=*,F4.2)
  108 FORMAT(2X,*NESTEFF=*,F10.3,2X,*REPRATE=*,F10.3,2X,*EGGS= *,F10.3)
  102 FORMAT(*0*,10X,*END OF *,A10)
  103 FORMAT(20X,*HARVEST DESIRED IS *,F6.2,* PERCENT*)
  104 FORMAT(20X,*NO FREEZE DURING WINTER*)
  105 FORMAT(20X,*FREEZE APPLIED DURING WINTER*)
  106 FORMAT(*0*,30X,*NEW AGE STRUCTURE*,/,40X,*MALES*,10X,*FEMALES*)
  107 FORMAT(32X,I2,2X,F9.0,7X,F9.0)
  109 FORMAT(*0*,20X,*TOTAL HATCHINGS FOR YEAR = *,F12.0,1X,*CONSISTING
     1OF *,F12.0,1X,*MALES AND *,F12.0,1X,*FEMALES*)
  110 FORMAT(2X,*PERCENTAGE OF EGGS  LOST DUE TO FLOODING =*,F5.1,/,2X,*
     1PERCENTAGE OF EGGS  LOST DUE TO PREDATION =*,F5.1)
  111 FORMAT(12X,*AVERAGE WATER LEVEL FOR MONTH IS *,F5.2)
  112 FORMAT(2X,*PERCENTAGE OF FEMALES NESTING =*,F5.1,1X,*YIELDING*,F10
     1.0,1X,*EGGS*)
      END
```



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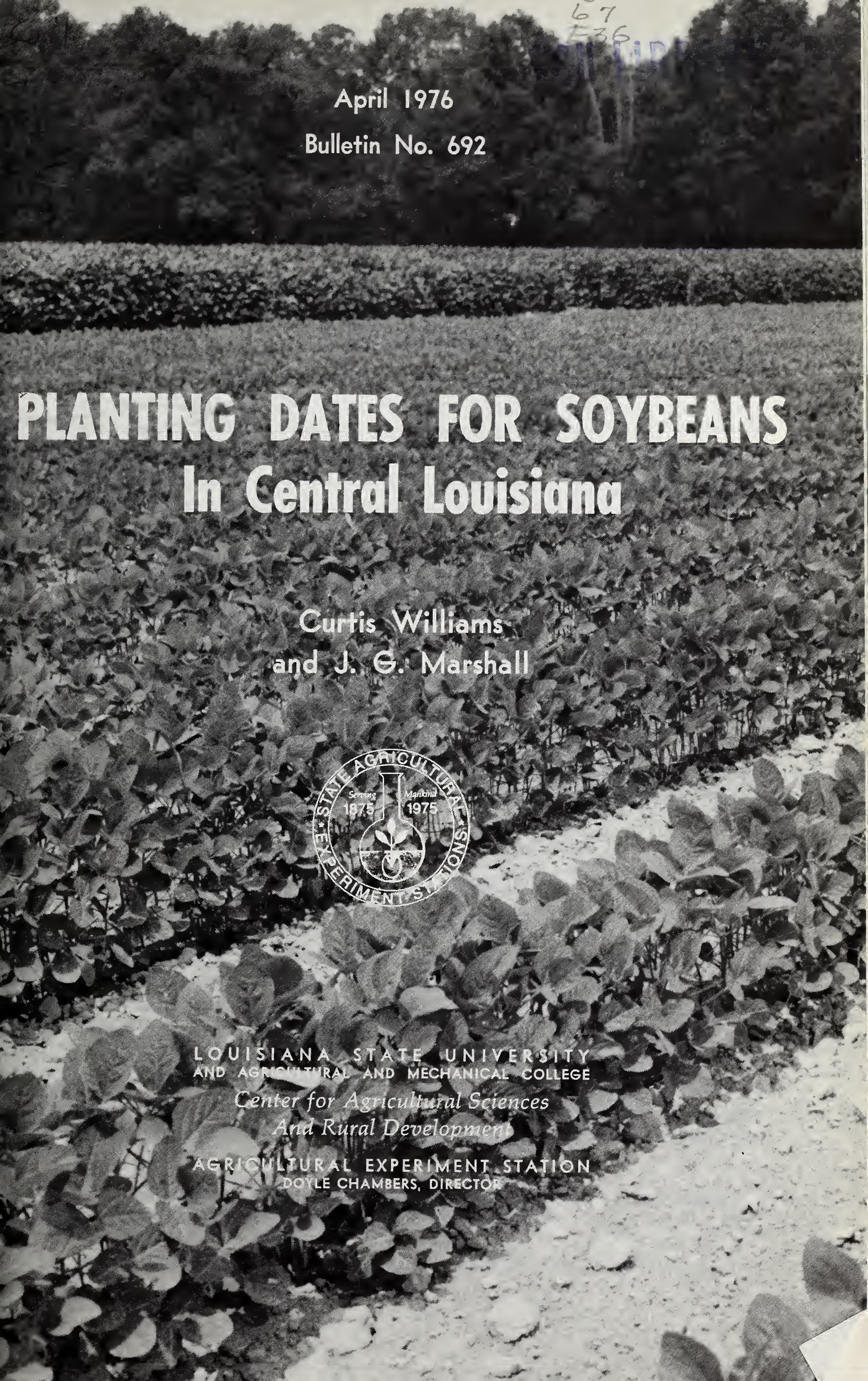

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PLANTING DATES FOR SOYBEANS In Central Louisiana

Curtis Williams
and J. G. Marshall

Serving Mankind
1875 1975

LOUISIANA STATE UNIVERSITY
AND AGRICULTURAL AND MECHANICAL COLLEGE
*Center for Agricultural Sciences
And Rural Development*

AGRICULTURAL EXPERIMENT STATION
DOYLE CHAMBERS, DIRECTOR

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Planting Dates for Soybeans In Central Louisiana

CURTIS WILLIAMS AND J. G. MARSHALL[1]

INTRODUCTION

Date of planting is one of the most important management practices in soybean farming. Each variety has an optimum planting date for a given locality. Yields decrease as soybeans are planted earlier or later than the optimum date. Fortunately, however, soybeans can be planted over a relatively long period of time without yields being too greatly affected. This attribute permits the soybean to be double-cropped with certain other crops grown in the area.

Many farmers grow large acreages of soybeans and may not be able to plant all their acreage during the optimum time. This is especially true if unfavorable circumstances prevent planting during the optimum time.

Soybean varieties differ in growth habit, flowering date and sensitivity to day length. It would be expected that varieties of the same maturity group might have different lengths of time at which maximum or near maximum yields could be produced. Even differences of a few days may be of value. By planting varieties in sequence according to their performance at different dates of planting, a farmer can obtain a higher average yield for his farm.

LITERATURE REVIEW

Since soybeans are very sensitive to day length, they have not shown the favorable response to extremely early planting that corn has shown. Because each variety has an optimum day length, no single date of planting is usually best for all varieties. With only 12 hours of daylight most varieties flower in 21 to 38 days (*5*)[2]. Adapted southern varieties flower too early to make maximum growth at day lengths of less than 14½ hours (*5*). However, all determinate varieties grown in the South do not respond alike to day length. Graves *et al.* (*3*) found at Jackson, Tennessee, that Davis, Dare and Hill soybeans grew 10, 13 and 9 inches, respectively, after flowering began, but the Lee variety grew only 3 inches after flowering began when planted on April 15. When planted on May 1, Davis, Dare, Hill and Lee soybeans grew 7, 10, 7 and 4 inches, respectively, after flowering began.

---

[1] Associate Professor, Department of Agronomy, Louisiana Agricultural Experiment Station, Baton Rouge, and Associate Professor, Dean Lee Agricultural Center, Alexandria, respectively.

[2] Italic numbers in parentheses refer to list in References Cited, Page 12.

Low soil temperatures and the danger of frost restrict the planting of soybeans in the northern U.S. to no earlier than about the first week in May (*1*). Studies have shown that a minimum soil temperature of 65° F gives much better germination and growth than lower soil temperatures (*6*).

Day length is the main restriction to planting early in the South. Caviness (*2*) obtained higher yields in Arkansas from mid-May plantings than from mid-April or mid-June plantings. Mid-April plantings yielded more than mid-June plantings in most years. In Alabama, Thurlow (*7*) reported higher yields from early May plantings than from late May or June plantings. Gray (*4*) planted soybeans from March 6 through July 20 in Louisiana. He obtained highest yields for "crushing" types when planted in May and June. Hartwig (*6*) obtained best results from mid-May plantings in Mississippi.

For a given locality the maturity date of late varieties was affected less by date of planting than the maturity date of early varieties (*1, 2, 5*). The reason was the greater effect of day length on the earlier varieties than on the later varieties (*1*). Therefore, yield of early varieties was usually reduced more with delay in planting than that of the late varieties (*2, 4, 5, 7*). Delayed planting of an early variety for a locality may give better seed quality if this places maturity in a good rainfall and temperature pattern (*1*). Late planting can increase lodging because the higher temperatures and longer days are favorable for rapid vegetative growth (*1*).

Gray (*4*) observed blooming and pod formation with subsequent shedding of both flowers and pods throughout the spring and summer when four "crushing" types were planted in March and April. Of the varieties tested, Lee was the most pronounced in this characteristic. It had ripening pods as well as blooms by June 23. Most of the pods were empty. Early planting increases the potential weed control problems since seed germinate slower and plants grow more slowly and are shorter than those planted at optimum times (*2, 4, 5*).

PROCEDURE

Hill, Davis, Ransom and Coker Hampton 266A soybeans were planted on April 20, May 20 and June 20 in 1971, 1972 and 1973. An adequate stand was not obtained from all varieties on all dates in 1973, and the data are not shown for that year. In 1974 the Coker Hampton 266A variety was dropped and the planting was expanded to five dates: April 10, May 3, May 31, June 25 and July 25. In all years, the plantings were at the Dean Lee Agricultural Center, Alexandria, La.

All plots were planted with a conventional 4-row tractor-mounted planter. The test was planted on Norwood silty clay loam in 1971 and on Norwood silt loam in 1972 and 1974. The pH of the soil was 7.5, 7.5 and 8.1 in 1971, 1972 and 1974, respectively. The extractable phosphorus, calcium and magnesium was "high," the percent soil organic matter was "low" and extractable potassium was "medium." Approximately 12 seeds per linear foot of row (about 45-50 pounds of seed per acre) were planted 1 to 2 inches deep on beds. Since nodulated soybeans were grown in the test field previously, seeds were not inoculated. No fungicide seed treatment was used prior to planting. Weed control was maintained with the use of herbicides and cultivation. Insecticides were applied as needed to control insects.

Four 40-inch-spaced rows, 85 feet long, were planted each of the years except in 1974, when rows were 80 feet long. The plots were arranged in a modified split-plot design with four replications. Dates of planting were the main plots and varieties the sub-plots. A good stand was obtained on all plots each year with one exception; the April 20 planting of the Hill variety in 1972 was only fair.

Yields were based on combine-run samples harvested from the center two rows of each plot. Yields in bushels per acre are reported on the basis of 60 pounds per bushel.

Plant height was determined as the average height of plants in a plot from the ground to the top extremity at maturity.

Maturity was taken as the date when the pods were dry and most of the leaves had fallen. Usually the stems were dry also.

Lodging was recorded on a scale of 1 to 5 according to the following criteria:

1 — almost all plants erect
2 — either all plants leaning slightly, or a few plants down
3 — either all plants leaning moderately, or 25 to 50% of the plants down
4 — either all plants leaning considerably, or 50 to 80% of the plants down
5 — all plants down

Height of lower pods was recorded as the average height of lowest pods from the ground.

Seed quality was rated on a scale from 1 to 5 according to the following scale: 1 — very good; 2 — good; 3 — fair; 4 — poor; 5 — very poor. The factors considered in estimating seed quality were development of seed, wrinkling, brightness and disease.

STATISTICAL ANALYSIS

Yield data from the 1971 and 1972 tests were combined for statistical analysis, since planting dates and varieties were comparable. Yield data from the 1974 test were analyzed separately. Yield differences were determined by use of the Tukey's Honestly Significant Difference Procedure (H.S.D.) at the 5% level.

RESULTS

For the tests grown in 1971 and 1972, highest mean yield for each variety was obtained from the May 20 planting (Table 1). Yields of the Davis variety did not differ significantly when it was planted on April 20 or May 20, but decreased 20% when planted on June 20. The Hill variety yielded only 9% less when planted on April 20 than when planted on May 20, but yielded 37% less if planting was delayed from May 20 to June 20. The stand of Hill was only fair for the April 20 planting in 1971. The Ransom and Coker Hampton 266A varieties yielded 24% and 21% less, respectively, when planted on April 20 than when planted on May 20, but yields were only decreased 12% for each variety by delaying planting to June 20.

The length of growing season decreased for each variety as planting date was delayed (Table 2). A delay of 61 days in planting resulted in a difference of 25 days in maturity of Hill soybeans, but only 10 days difference in maturity of the Davis variety and 17 days difference in the Ransom variety. The Coker Hampton 266A variety did not mature normally. The leaves did not shed properly, and stalks remained green beyond the normal maturity date.

Table 1.—Effect of planting date on the yield of four soybean varieties grown at Alexandria, La., 1971-72

	Planting date			
Variety	April 20	May 20	June 20	Mean
	- - - - - - - - - - - -	bushels per acre	- - - - - - - - - - - -	
Hill	33.7 (91)[1]	37.1 (100)	23.2 (63)	31.3
Davis	48.1 (98)	48.9 (100)	38.9 (80)	45.3
Ransom	35.7 (76)	47.0 (100)	40.8 (88)	41.2
Coker Hampton 266A	25.4 (79)	32.2 (100)	28.3 (88)	28.6
Mean	35.7	41.3	32.8	

[1] Yield as a percent of highest yield for given variety.

H.S.D. at 5% level for comparing two varieties = 1.4 bushels.
H.S.D. at 5% level for comparing two varieties at same date = 2.1 bushels.
H.S.D. at 5% level for comparing two dates for same variety = 1.7 bushels.

Table 2.—Effect of planting date on selected characters of four soybean varieties grown at Alexandria, La., 1971-72

Planting date and variety	Maturity date	Length of growing season, days[1]	Plant height, inches	Lodging[2]	Seed quality[3]	Height of lower pods, inches
April 20						
Hill	Sept. 4	137	26	1.5	2.4	3.0
Davis	Oct. 10	173	34	1.1	3.2	4.0
Ransom	Oct. 18	181	23	1.1	2.6	3.0
Coker Hampton 266A	Nov. 6	200	38	1.2	4.2	6.5
May 19						
Hill	Sept. 14	118	32	1.0	2.4	3.5
Davis	Oct. 12	146	38	2.0	3.0	6.0
Ransom	Oct. 27	161	38	1.6	2.3	6.0
Coker Hampton 266A	Nov. 17	182	46	2.0	3.9	7.5
June 20						
Hill	Sept. 29	101	24	2.0	2.0	3.0
Davis	Oct. 20	123	36	2.4	2.4	4.5
Ransom	Nov. 4	137	32	1.8	2.4	6.0
Coker Hampton 266A	Nov. 17	150	36	2.6	3.8	5.0

[1] Days from planting to maturity.

[2] 1 = no lodging, 5 = all plants down.

[3] 1 = very good seed quality, 5 = very poor seed quality.

Plant height was reduced when each of the varieties was planted either earlier or later than May 20 (Table 2). Of the four varieties tested, the Ransom variety was most adversely affected by planting early. Lodging tended to increase with delay in planting, but seed quality improved slightly as planting was delayed.

In 1974, highest yields were obtained for each of the three varieties from planting on May 3 (Table 3). The Hill and Davis varieties each yielded the same when planted on April 10 and May 31. The Ransom variety reacted differently, yielding only 80% as well when planted on April 10, but yielding only 7% less when planting was delayed until May 31. Davis and Ransom soybeans yielded about the same when planted on June 25, but the yield decrease from the May 3 planting was less for Ransom than for Davis. The trend for earlier varieties to decrease in yield at a faster rate as planting was delayed was reversed for the July 25 planting. The earliest variety, Hill, yielded more than the latest variety tested. As an average of varieties, yield decreased at the rate of about ½ bushel per day from June 1 to July 25 (Figure 1).

Hill soybeans planted on April 10 matured on August 24 (Table 4). The length of growing season decreased for each of the three varieties as planting date was delayed. Maximum plant growth occurred for Hill and Ransom soybeans when planted on May 31. The Davis variety reached a maximum height of 40 inches when planted on May 3 and May 31. Seed quality was best from plantings made on May 31 and June 25. The poor seed quality of each variety planted on April 10 and of the Hill variety planted May 3 was partially due to delayed harvesting.

Table 3.—Effect of planting date on the yield of three soybean varieties grown at Alexandria, La., 1974

	Planting date					
Variety	April 10	May 3	May 31	June 25	July 25	Mean
	- - - - - - - - - - - -		bushels per acre		- - - - - - - - - - - -	
Hill	40.1 (91)[1]	43.9 (100)	40.1 (91)	28.8 (66)	19.0 (43)	34.4
Davis	44.4 (90)	49.3 (100)	44.4 (90)	34.0 (69)	17.0 (34)	37.8
Ransom	37.2 (80)	46.3 (100)	43.2 (93)	33.8 (73)	11.6 (25)	34.4
Mean	40.6	46.5	42.6	32.2	15.9	--

[1] Yield as a percent of highest yield for a given variety.
H.S.D. at 5% level for comparing two varieties = 2.4 bushels.
H.S.D. at 5% level for comparing two varieties at same date = 5.5 bushels.
H.S.D. at 5% level for comparing two dates for same variety = 6.4 bushels.

Height of lower pods of the Ransom variety planted on April 10 and May 3 was not high enough to permit combining without some seed loss. The same was true for Ransom and Davis soybeans planted on July 25.

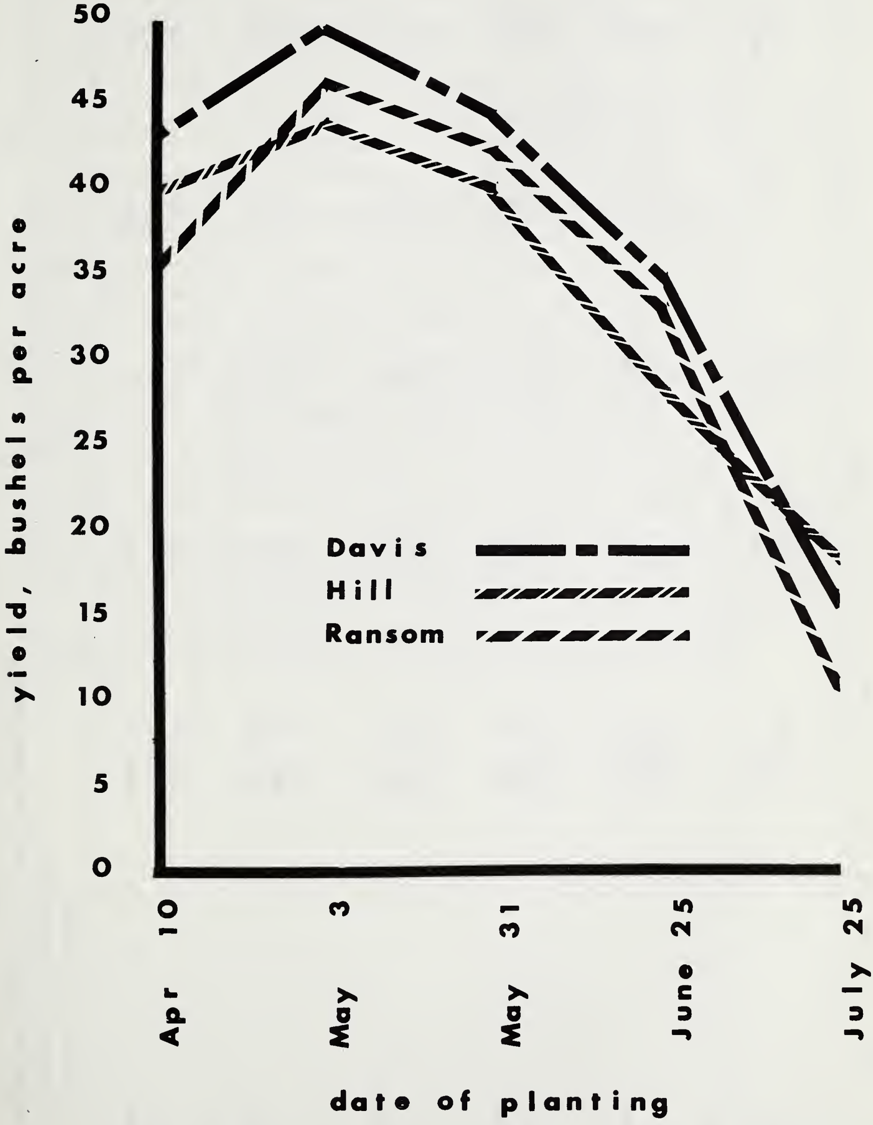

Figure 1.—Yield of three soybean varieties when planted on different dates at Alexandria, La., 1974.

Table 4.—Effect of planting date on selected characters of three soybean varieties grown at Alexandria, La., 1974

Planting date and variety	Maturity date	Length of growing season, days[1]	Plant height, inches	Lodging[2]	Seed quality[3]	Height of lower pods, inches
April 10						
Hill	Aug. 24	136	26	2.0	4.4	3.0
Davis	Sept. 21	164	35	2.0	3.0	5.0
Ransom	Sept. 23	166	18	1.0	3.0	2.0
May 3						
Hill	Sept. 1	120	30	2.0	4.0	4.0
Davis	Sept. 30	150	40	2.0	2.5	5.0
Ransom	Oct. 4	154	21	1.0	2.5	1.0
May 31						
Hill	Sept. 15	108	34	3.0	2.0	4.0
Davis	Oct. 10	133	40	2.0	2.0	4.0
Ransom	Oct. 15	138	39	3.0	2.0	5.0
June 25						
Hill	Oct. 2	99	25	3.0	2.0	3.0
Davis	Oct. 9	106	32	3.0	2.0	3.0
Ransom	Oct. 20	117	—	1.0	2.0	4.0
July 25						
Hill	Oct. 20	87	18	3.0	2.8	3.0
Davis	Oct. 27	94	18	2.0	2.5	2.0
Ransom	Nov. 1	99	17	2.0	2.5	2.0

[1] Days from planting to maturity.

[2] 1 = no lodging, 5 = all plants down.

[3] 1 = very good seed quality, 5 = very poor seed quality.

DISCUSSION

Results from these tests indicate that on well drained, fertile loam soils with low weed pressure, the Davis and Hill varieties can yield very well in Central Louisiana when planted on beds in April. Average maximum yields of these two varieties occurred from May plantings, but yields from mid-April plantings were well above mid-June plantings. As an average of dates of planting, the Davis variety had the highest mean yield of the varieties tested.

The Ransom variety generally produced higher yields and had better plant growth from May and June plantings than from April plantings. It appeared to be more sensitive to short days than either Hill or Davis.

There are potential problems from planting soybeans in April in Louisiana. These include poor germination due to cold, wet soils, slow plant growth if the temperature is below normal and seed quality problems at harvest. Only seed of highest quality should be used for planting in April. Also, seed should be treated with a fungicide. Seed should be planted as shallow as moisture conditions will permit. The Hill variety planted on April 10 to May 1 will mature in late August or early September in Central Louisiana, when temperatures are high and frequent showers occur. Under these conditions soybean seed deteriorate very rapidly. Only a relatively small percentage of a farmer's acreage should be planted with Hill before May 1 in Central Louisiana. The early maturing soybeans should be harvested as soon as possible to reduce the amount of damaged seed. The Davis variety planted on April 10 to May 1 will mature in late September to early October, when weather conditions are normally somewhat better than in early September or late August. For best yields and harvesting efficiency, the Ransom variety should only be planted in May and June in Central Louisiana.

(See Page 12 for References Cited)

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Restudy of Toledo Bend Reservoir User Characteristics

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Restudy of Toledo Bend Reservoir User Characteristics

ALVIN L. BERTRAND, STEPHEN E. DOEREN AND YUI HUEN KWAN*

Introduction

Americans are turning to recreational activities in increasingly greater numbers. It is estimated, for example, that consumer expenditures for recreational purposes now approach $250 billion annually, or 12 percent of our total national spending.[1] This trend is associated with such factors as longer vacations, 3-day weekends, increasing income, and early retirement. All in all, recreation is an important and economically vital aspect of our national life.

The states of the South are in a particularly strategic position to take advantage of the national trend toward outdoor recreation. A climate conducive to year-round recreation and an abundance of natural resources make the region attractive for outdoor recreational activities. It is not surprising that recreation (and tourism) is seen as a "growth industry" which has a very great potential in the region.

This report derives its relevance from the above facts. The findings presented are from a follow-up study of the recreationist users of Toledo Bend, a large multipurpose reservoir created in 1968 by damming the Sabine River. It is hoped that the information presented will be of use in the continuous planning and development which must be done to maintain and increase the attractiveness of such a facility for recreationists and tourists.

Objectives of the Study

The three major objectives of the study were pragmatically oriented. Each was inspired by a wish to contribute to an enlightened development and management of the recreational activity at Toledo Bend. In this regard, both the state and the Sabine River Authority have a vested interest in the orderly and efficient operation of this huge facility. The interest of the state is expressed in a recent report released by the Louisiana Parks and Recreation Commission entitled, "Outdoor Recreation in Louisiana, 1975-1986." In this report a long range goal, to "Insure recreational opportunities in the broadest sense, now and in the future, for all the people," is stressed. The interest of the Sabine River Authority is inherent in that one of its major responsibilities is to provide the best possible recreational facilities for Toledo Bend.

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[1] *Natural Resources Research Needs in Recreation and Wildlife* (Washington, D.C., Southern Region Agricultural Experiment Stations and U.S. Department of Agriculture, 1974) p. 1.

Objective No. 1 was to determine changes in the recreational uses and in the characteristics of users of Toledo Bend over a 3-year period. The first study, completed in 1971, served as a base line for the comparisons necessary to achieve this objective. Two considerations made this first goal especially pertinent. The first is the tendency of fish yields to drop rather drastically in reservoirs after the first few years. Since fishing was the chief recreational attraction at Toledo Bend at the time of the first survey, it was expected that some changes would occur as fish yields declined. The second consideration was the impact of developments which occurred at Toledo Bend over the period of time covered. For example, telephones were made available, some roads were built, overnight facilities were added, and many second homes were built.

The second major objective of the study was to determine the nature of problems as perceived by users of Toledo Bend and to make comparisons with the problems perceived 3 years earlier. Again, it was clear that some of the "convenience" and "access" problems should not be as acute as they were earlier, but there was little information on what was considered needed and vital in the way of continuing development.

Finally, it was a major aim to contribute to the understanding of the "life cycle" of a rural development project, such as Toledo Bend Reservoir represented. There is much hope expressed that wise husbandry of our natural resources will help alleviate major societal problems, such as unemployment and urban congestion, as well as decrease the shortage of recreation areas. After 8 years of existence, it was felt that Toledo Bend would offer some indications of whether or not such hopes are realistic.

Background of the Study

The Toledo Bend dam and lake were built through a cooperative effort between Texas and Louisiana, with the flooding being completed in May of 1968. This project was designed to serve as a multipurpose facility to generate hydroelectric power, to conserve water, and to improve and to provide outdoor recreation. The reservoir is 65 miles long, with an average width of 3 miles. It covers 181,000 acres at its normal level of 172 feet above sea level and ranges in depth from 10 to 12 feet at its upper end to 84 feet in the Old River channel at the base of the dam. The dam site is located approximately 18 miles west of Leesville, Louisiana. For the main part, the reservoir covered land that was relatively infertile for agriculture, although suitable for timber growth, and uninhabited. This part of Louisiana was considered economically depressed before the reservoir was built, although there is now indication of economic growth.[2]

Since the inauguration of the Toledo Bend project, the Sabine River Authority has been concerned with development of the reservoir in the best and most expeditious manner. To this end, several studies have been conducted to determine needs and the feasibility of certain programs. The authors of the most recent study, released in 1975, conclude that Toledo Bend has the potential for a highly successful outdoor recreation and tourist program, although development to date has not been extensive. An expenditure of $8.5 million is recommended, mostly for roads, to achieve the level and type of development felt necessary.[3]

The present report, as the one prepared previously, is submitted in the interest of providing members of the Sabine River Authority and others in responsible positions with information helpful for further development. Basically, data is provided on changes over time with some suggestions made as to what these changes may portend in the way of future uses.

Methodological and Analytical Approach

The approach to this follow-up study was an on-site survey similar to that conducted in connection with the first investigation. However, data collection was compressed to one week, August 12-18, 1974, whereas for the original study interviewing was done primarily over the period July to September of 1971. In each instance the universe for study was all persons using the Louisiana side of Toledo Bend Reservoir for recreation purposes.

At the time of the restudy, teams of enumerators spent a minimum of 2 days (not consecutive) at all marinas (or commercial access locations) on the Louisiana side of the reservoir and visited all camping sites on 2 non-consecutive days. Also, persons fishing or launching boats at non-commercial places along the shoreline were checked on two separate occasions. Only one adult per recreation group was interviewed, and the interview *was* conducted in a face-to-face fashion. While the sampling procedure was not random, it is felt that a sufficient number of interviews were obtained to assure a reasonably accurate picture of the users of Toledo Bend and of their feelings and attitudes about the reservoir. Altogether, 436 interviews were completed during the second or restudy phase of the project.

The analytical procedure followed was simple and straightforward. Tables were prepared to show findings relative to a given question at the time of the first study and at the time of the restudy. Differences in frequencies of responses were noted and accounted for when information was available for the two time periods. All discussions proceed from the perspective of the future needs for orderly and wise development of the reservoir for recreational purposes. The text is organized to parallel the discussions contained in the report of the first study.

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[2] A recent study commissioned by the Sabine River Authority indicates an extensive business community developed on Toledo Bend soon after the lake filled. *Development Plan for Toledo Bend: Executive Summary of Findings and Recommendations,* Planning and Research Associates, Inc., 1975.

[3] *Ibid.*

Demographic Characteristics of Toledo Bend Users: 1974 Restudy

There is a question of whether a recreation facility such as Toledo Bend retains its popularity year after year for the same type of individual. One would normally suppose that at least some subtle changes in this regard would take place, if for no other reason than changes in the development of the facility—for better or for worse. In the particular case of Toledo Bend, it was a rather well known fact that fishing was not as productive as 3 years earlier, while at the same time more facilities were available. There was a strong interest by the researchers in determining who came to the reservoir in 1974 and in determining if the users had different characteristics than in 1971. Findings of the restudy in this regard are presented so comparisons can be made with findings of the previous study.

Occupation

Occupations of family heads were classified according to the broad job categories used in the U.S. Census, with designations of "student," "military," and "retired," added. The tacit assumption was made that the male's occupation was the principal occupational classification for the family. To determine how representative the users of Toledo Bend were of the work force of the state and nation, the occupations of the study population were compared with the occupational distribution of white males 16 and above for both Louisiana and the nation (see Table 1).

Based on the findings of the first study, it was expected there would be a slight over-representation of the upper income occupational categories among the respondents. The data collected at the time of the restudy offer convincing evidence that the level of affluence of users has risen in 3 years.

Toledo Bend users in 1974, as shown by data in Table 1, still tended to come from what may be termed the broad middle-class strata. However, among the users the first occupational group (professional, technical, and kindred workers) and the second occupational group (managers, officials, and proprietors) were much more over-represented at the time of the restudy than at the time of the first study. The occurrence among

Table 1.—Occupations of Toledo Bend users sampled in 1971 and 1974

Occupation	(1974) % of total Toledo Bend restudy sample		(1971) % of total Toledo Bend first study sample		% of 1970 occupations of white males 16 and over*		(1974) % of total Toledo Bend restudy sample, Louisiana residents only		(1971) % of total Toledo Bend first study sample Louisiana residents only	
	Actual	Adjusted[1]	Actual	Adjusted[1]	U.S.	La.	Actual	Adjusted[1]	Actual	Adjusted[1]
Professional, technical, & kindred workers	20.9	24.2	11.1	14.6	14.6	11.7	22.0	25.7	11.2	13.6
Managers, officials & proprietors	18.6	21.5	17.3	21.0	18.9	9.2	18.9	22.1	17.4	21.1
Clerical & kindred workers	4.1	4.8	4.5	5.4	7.5	6.7	5.1	5.0	5.1	5.0
Sales workers	7.1	8.2	7.8	9.4	6.1	6.2	7.8	9.4	7.8	9.4
Craftsmen, foremen, & kindred workers	16.3	18.8	14.9	18.0	20.8	21.7	15.1	17.6	14.5	17.6
Operatives & kindred workers	11.9	13.8	21.2	25.7	18.7	20.6	11.3	13.1	21.5	26.0
Service workers (includes household)	3.7	4.2	2.0	2.4	6.1	7.8	3.9	4.5	2.2	2.7
Laborers (includes farm)	3.9	4.5	3.8	4.6	7.9	11.9	4.4	5.0	3.9	4.7
Students	4.3		4.0				4.9		4.3	
Retired	0.7		7.6				0.8		6.5	
Military	4.2		2.6				4.1		3.1	
Other	3.2		1.8				3.1		1.6	
No information	1.1		1.5				1.3		1.8	
	N=436	N=377	N=605	N=499			N=390	N=335	N=489	

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[1] Adjusted excludes students, retired, military, other, and no information.

*Source: Handbook of Labor Statistics, 1971, U.S. Department of Labor, Bureau of Labor Statistics, Washington, D.C.

the respondents of both categories of occupational groups was twice what could be expected from their occurrence in the population of the state at large. Comparison with national patterns of occupational distribution shows that professional, technical, and kindred workers were considerably over-represented while managers, officials, and proprietors were only slightly over-represented in the restudy group. Slightly under half (45.7 percent) of the Toledo Bend users interviewed were classified in these two highest occupational categories.

Findings of the restudy were similar to those of the first study for the remainder of the occupational groups—clerical and kindred workers were slightly under-represented; sales workers were slightly over-represented; craftsmen, foremen, and kindred workers were slightly under-represented, and service workers were under-represented. There was, however, a notable difference in the operatives and kindred workers occupational category. In the first study, those working in this class of occupations were over-represented among Toledo Bend users, in the restudy they were under-represented.

The change in the occupational background of Toledo Bend users may indicate that greater difficulty in catching fish has caused the reservoir to become less popular with those in the working classes, who more likely would be "meat" or "natural bait" fishermen. In contrast, the appeal may have increased for the sport fisherman who can afford a well-equipped bass rig and enjoys fishing for sport rather than to replenish his freezer stock of fish.

Age and Sex

A breakdown of the age and sex of the persons interviewed is presented in Table 2. For the first study, all members of a given recreational group were included in the age tables, while in the restudy only the respondent was included.[4] The census age-sex composition of the white population of Louisiana in 1970 is given to provide a basis of comparison in both Table 1 and 2. It was expected at the time of the first study that men would be encountered in much greater numbers than women among users of Toledo Bend. In actual fact, men were found to outnumber women, but the difference was not that great (1,709 males versus 1,227 females). In the restudy, men outnumbered women by a large margin, but this was due to only one person per group being interviewed. Of the 436 respondents, 358 were males and 78 were females. The age distribution for male and female respondents was very similar (Table 3). Interestingly, there was no particular "lumping" of a given age among users of either sex.

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[4] It should be noted that the absence of individuals in the 17 and under bracket is attributable to the fact that only the respondent was included in the restudy data and the respondent was usually either the father or mother, or the so-called leader of the group.

A study of Table 2 shows that less than 1 percent of the respondents were 14 to 17 years old, and less than 5 percent were in the 18 through 24 age category. Again, this is because the age of only one person, the delegated or avowed leader, from each group was recorded. One-fifth (19.5 prcent) of the respondents were 25 through 34 years of age, one-fourth (24.7 percent) were in the 35 through 44 age bracket, and one-fifth (20.8 percent) were in the 45 through 54 age range. A decreasing number of persons, relatively speaking, were 55 through 64 years of age (13.8 percent) and 65 years old and over (8.5 percent).

Table 2.—Age and sex characteristics of Toledo Bend users sampled in 1974

Age (years)	Total sample	% of total sample	No. of males	% of males	No. of females	% of females	% of all La. whites in age groups*
Under 5	0	0.0	0	0.0	0	0.0	8.7
5-13	0	0.0	0	0.0	0	0.0	18.6
14-17	3	0.6	3	0.8	0	0.0	8.0
18-24	18	4.1	17	4.8	1	1.3	12.2
25-34	85	19.5	68	19.0	17	21.8	12.6
35-44	108	24.7	86	24.1	22	28.2	11.5
45-54	91	20.8	73	20.0	18	23.1	11.1
55-64	60	13.8	50	14.0	10	12.8	8.8
65+	37	8.5	35	9.9	1	1.3	8.5
No response	35	8.0	26	7.4	9	11.5	
Total	436	100.0	358	100.0	78	100.0	100.0

*Source: U.S. Bureau of the Census, Census of Population: 1970, General, Social, and Economic Characteristics, Final Report PC (1) -C 20 Louisiana.

Table 3.—Age of male and female Toledo Bend users sampled in 1974 serving as leaders of their party

Age (years)	Total sample	No. of males	% of males	No. of females	% of females
14-17	3	3	100.0	0	0.0
18-24	18	17	94.4	1	5.6
25-34	85	68	80.0	17	20.0
35-44	108	86	79.6	22	20.4
45-54	91	73	80.2	18	19.8
55-64	60	50	83.3	10	16.7
65+	37	35	94.6	1	5.4
No response	35	26	74.3	9	25.7
Total	436	358		78	

Education

The findings relative to the educational attainment of Toledo Bend users at the time of the first study and restudy are compared with white Louisiana residents age 25 and over in Table 4.[5] Examination of this table shows that the lower educational levels are under-represented and the upper levels are over-represented among the user population. In this regard, the findings of the restudy were consistent with the findings of the first Toledo Bend study and with those of studies done elsewhere.[6]

According to the 1970 U.S. Census, close to one-third (30.8 percent) of white Louisiana residents 25 years old had 8 years or less of schooling. However, less than one-tenth (8.3 percent) of the Toledo Bend restudy respondents from Louisiana (out-of-state users were not included in this computation) were in this category. By contrast, about one-fifth (19.2 percent) of the white Louisiana residents 25 years and over had 9 through 11 years of schooling at the time of the 1970 Census, but only 13.6 percent of the respondents from Louisiana were in this educational class. Approximately one-third (33.9 percent) of the Louisiana respondents in the restudy had been graduated from high school, as compared with 28.9 percent of the white residents of the state 25 years and over.

The users interviewed who had completed more than a high school education were highly over-represented in the restudy population when compared with the state's population. For example, respondents with 13 through 15 years of formal schooling were found in numbers two times greater than would be expected from the relative presence of this educational level in the state population. Nearly one-fourth (23.1 percent) of the respondents from Louisiana were in this educational category, while only one of every 10 (10.3 percent) white Louisiana residents 25 years and over have achieved this high an education. At the college level of education (16 years or more of formal schooling) the respondents were again over-represented when compared with the state's population. Whereas only 10.8 percent of the white Louisiana residents 25 years and over have achieved this level of education, 21 percent of the users of Toledo Bend from Louisiana said they had gone this far with their formal schooling.

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[5] These comparisons should be interpreted with caution because (1) 21 of the respondents in the total sample were under 25 years of age, and (2) there were but 78 females included in the total sample.

[6] Outdoor Recreation Resources Review Commission, *Prospective Demand for Outdoor Recreation* (Washington, D.C., U.S. Government Printing Office, 1962), pp. 19-28. Outdoor Recreation Resources Review Commission, *Participants in Outdoor Recreation: Factors Affecting Demand Among American Adults* (Washington, D.C., U.S. Government Printing Office, 1962), p. 11. William R. Burth and Wiley D. Wenger, Jr., *The Social Characteristics of Participants in Three Styles of Family Camping,* U.S. Forest Service Research Paper PNW-48, 1967, p. 19.

Table 4.—Educational attainments of Toledo Bend users sampled in 1971 and 1974

Education in years	Restudy (1974)							First study (1971)							Education of white La. residents 25 yrs. & over**
	Total sample			Louisiana only			La. only as % of category	Total sample			Louisiana only			La. only as % of category	
	No.	%	Adj. %*	No.	%	Adj. %*		No.	%	Adj. %*	No.	%	Adj. %		
Less than 8	26	6.0	6.1	25	6.4	6.5	96.2	18	3.0	3.0	14	2.9	2.9	77.8	22.5
8	11	2.5	2.6	7	1.8	1.8	63.6	24	4.0	4.1	19	3.9	4.0	79.2	8.3
9-11	57	13.1	13.3	53	13.6	13.7	93.0	59	9.6	10.0	54	11.0	11.3	91.5	19.2
12	145	33.3	33.6	131	33.6	33.9	90.3	258	42.6	43.7	210	42.9	43.9	81.4	28.9
13-15	102	23.4	23.7	89	22.8	23.1	87.3	100	16.5	16.9	75	15.3	15.7	75.0	10.3
16	51	11.7	11.9	45	11.5	11.7	82.2	81	13.4	13.7	61	12.5	12.8	75.3	6.5
Over 16	38	8.7	8.8	36	9.3	9.3	94.7	51	8.4	8.6	45	9.2	9.4	88.2	4.3
No information	6	1.3		4	1.0			14	2.3		11	2.2			
	N=436		N=430	N=390		N=386		N=605		N=591	N=489		N=478		

*Adjusted excludes "no information" category.

**Source: U.S. Bureau of the Census, Census of Population: 1970, General. Social, and Economic Characteristics, Final Report PC (1) – C 20 Louisiana.

Family Income

All respondents were queried regarding the total annual income of their immediate family. The distribution of responses to this question is shown in Table 5. Family income is also shown for white family groups of the state in 1970. For comparative purposes, the 10 nonwhites (including nine blacks) in the user sample were not included in the compilation of family income data.

The distribution of white respondents among the various family income classes for the Toledo Bend user sample and for the Louisiana resident sub-sample shows considerable difference. Persons with family incomes of less than $10,000 were greatly under-represented among the Toledo Bend users interviewed. Close to three-fifths (58.6 percent) of the white families in Louisiana have an income within this range, according to the 1970 U.S. Census, but only 22.9 percent of the Toledo Bend users from Louisiana said their family income was in this range. Said another way, the percentage of Toledo Bend users in the upper income group was almost twice what would be expected, based upon the number of families in the state population with incomes in this range. These findings are consistent with those of the first Toledo Bend study and provide clear evidence of the relative affluence of the Toledo Bend recreationist population.

Table 5.—Family income of white Toledo Bend users sampled in 1974 compared with white Louisiana users in sample population and white Louisiana residents

	Family income of white respondents				Family income of white Louisiana residents, 1970*
Annual income (dollars)	No. all respondents	No. La. respondents	% all respondents	% La. respondents	%
Below 2,500	13	13	3.1	3.4	23.1
5,000-7,499	12	12	2.8	3.2	
5,000-7,499	35	28	8.2	7.4	35.5
7,500-9,999	38	34	8.9	8.9	
10,000-12,499	60	53	14.1	13.9	41.4
12,500-14,999	76	72	17.8	18.9	
15,000-19,999	90	80	21.2	21.0	
20,000-24,999	51	47	12.0	12.3	
25,000-above	47	38	11.0	10.0	
No information	4	4	0.9	1.0	
Total	426	381	100.0	100.0	100.0

*Source: U.S. Bureau of the Census, Census of Population: 1970, General, Social, and Economic Characteristics, Final Report PC (1)–C 20 Louisiana, p. 175.

As noted in the first report on Toledo Bend users, the findings presented above are consistent with the findings of other researchers.[7] As family income increases there is a definite increase in outdoor recreation, up to a level of income of about $25,000. After this level is reached there appears to be a decline in recreation activity of the type represented at Toledo Bend. The data from the present study do not indicate such a decline, but this may be because incomes are now reflecting a general inflationary trend. At any rate, there is evidence to suggest that camping and fishing are very popular among individuals of moderate to middle income.

Residence

To ascertain the size of the place of residence from which Toledo Bend users were more likely to come, respondents were asked what size town they lived in or whether they lived outside population centers. Responses were classified according to the U.S. Census classification.

In the restudy, population centers of 100,000 or more people were significantly under-represented in the user population interviewed (see Table 6). According to the 1970 Census, 29.5 percent of the state's population resided in places of at least 100,000 population. Of the Toledo Bend restudy user population sampled, only 10.1 percent said they were from urban centers of this size. However, the user group from towns ranging in size from 25,000 to 100,000 was over-represented. This size town makes up 11.2 percent of the state's population, but included 17.4 percent of the user population.

Table 6.—Size of place of residence of Toledo Bend users sampled in 1971 and 1974 compared with Louisianians in sample population and all Louisianians

Size of place of residence	Restudy (1974)						First study (1971)				La. census
	Total sample			La. sample			Total sample		La. sample		
	No.	%	Adj. %*	No.	%	Adj. %*	No.	%	No.	%	%
2,500 or less (incl. farm)	222	50.9	51.5	201	51.5	52.2	22	13.2	13	11.7	33.9
2,500 to 25,000	89	20.4	20.7	82	21.0	21.3	34	20.4	24	21.6	21.0
25,000 to 100,000	76	17.4	17.6	64	16.4	16.6	45	27.0	29	26.1	11.2
100,000 and over	44	10.1	10.2	38	9.7	9.9	66	39.6	45	40.5	29.5
No information	5	1.1		5	1.3						
	(N=436)			(N=390)			(N=167)		(N=111)		

*Adjusted percent excludes "no information" category.

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[7] Outdoor Recreation Resources Review Commission, *Participants in Outdoor Recreation: Factors Affecting Demand Among American Adults* (Washington, D.C., U.S. Government Printing Office, 1962), p. 27. Rex W. Cox and Jerome E. Johnson, *Outdoor Recreation Activities of North Dakota Residents* (Fargo, N.D., North Dakota State University, Dept. of Agricultural Economics, Agricultural Experiment Station, Agricultural Economics Report No. 72, 1972), p. 18.

In the instance of smaller towns, i.e. from 2,500 to 25,000 inhabitants, the representation among Toledo Bend users was approximately the same as was true in the population of the state in 1970. Somewhat surprisingly, persons from towns of 2,500 or less or living in the open country were much more in evidence among Toledo Bend users than their representation in the state's population would lead one to expect.

Two notable differences are apparent between the findings of the first study and the restudy. At the time of the original study, 11.7 percent of the Louisiana users lived in towns of 2,500 or fewer persons. In contrast, over half (52.2 percent) of the users interviewed at the time of the second study came from places of this size. In the second instance, slightly over two-fifths of the user population lived in a place with a population of 100,000 or more when the first study was made, but only about one-tenth (9.7 percent) of the users interviewed at the time of the second study lived in a place of residence this large.

It is difficult to account for these drastic differences in findings. However, the fact that in the first study a question on size of place of residence was asked of only a relatively small sub-sample (167 persons)[8] of the interviewees may be an explanation.

Place of Childhood Residence

In the restudy, as in the first study, respondents were asked to name their childhood place of residence. Responses given at the time of the restudy were very similar to those given at the time of the first study (see Table 7). Approximately one-third (33.6 percent) of the respondents

Table 7.–Size of childhood place of residence of Toledo Bend users sampled in 1971 and 1974

Size of place of residence	Restudy (1974)			First study (1971)		
	No.	%	Adjusted %*	No.	%	Adjusted %*
Farm	145	33.3	33.6	189	31.2	33.0
Rural non-farm	54	12.4	12.5	99	16.4	17.3
Less than 2,500	23	5.3	5.4	43	7.1	7.5
2,500-10,000	42	9.6	9.7	49	8.1	8.6
10,000-25,000	47	10.8	10.9	38	6.3	6.7
25,000-50,000	40	9.2	9.3	38	6.3	6.7
50,000-100,000	36	8.2	8.4	40	6.6	7.0
100,000-250,000	27	6.2	6.3	40	6.6	7.0
250,000+	17	3.9	3.9	35	5.8	6.2
No information	5	1.1		34	5.6	
	(N=436)		(N=431)	(N=605)		(N=571)

*Adjusted excludes "no information" category.

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[8] Such a question was added as an afterthought rather late in the study.

reported they grew up on a farm, 12.5 percent said they were from rural nonfarm places, and 15 percent reported growing up in places of less than 10,000 inhabitants. From these findings, it appears that persons who grew up in rural areas are very active participants in those types of outdoor recreation available at Toledo Bend.

Characteristics of Recreation Expeditions: 1974 Restudy

Distance Traveled

An interesting trend is evident from a comparison of the distance traveled by the users queried at the time of the restudy and those interviewed earlier. This is the tendency for users to come from shorter distances. For example, at the time of the latest study almost one-quarter (23.9 percent) of the persons interviewed had traveled 75 or fewer miles to get to Toledo Bend (see Table 8). By contrast, only 13.9 percent of the persons quizzed at the time of the first study had come from places this close. Also providing evidence of this trend is the fact that only 24.7 percent of the users interviewed in 1974 had traveled 200 or more miles to get to Toledo Bend. In 1971, about one-third (33.9 percent) of the users interviewed had traveled at least 200 miles. This trend could be a reflection of the increased difficulty of catching fish at Toledo Bend. When a large catch is not a sure thing, people often will not consider a long drive worthwhile, particularly in view of the substantial increases in gasoline prices in recent years.

Table 8.—Distance traveled to get to Toledo Bend by users sampled in 1971 and 1974

Distance traveled (miles)	Restudy (1974)		First study (1971)	
	No. of persons	Percent	No. of persons	Percent
0-49	37	8.5	31	5.1
50-74	67	15.4	53	8.8
75-99	81	18.6	117	19.3
100-149	95	21.8	127	21.0
150-199	48	11.0	72	11.9
200-249	47	10.8	94	15.5
250-299	16	3.7	32	5.3
300-499	30	6.9	39	6.5
500+	14	3.3	40	6.6
Total	435*	100.0	605	100.0

*There was one missing value excluded from the restudy totals.

Day of Arrival

The findings of the restudy indicate that Friday continues to be the most popular day of the week for arrival of recreationists at Toledo Bend. Saturday also held its rank as the second most popular day for users to arrive. In the restudy, 29.7 percent of all arrivals were on Friday and 16.1 percent were on Saturday. At the time of the first study, 29.3 percent of the respondents came in on a Friday and 22.5 percent of them arrived on Saturday. The number and percentage of interviewees arriving on a given day of the week at the time of the restudy and at the time of the first study are shown in Table 9.

Whereas at the time of the first study only 13.4 percent of all arrivals appeared during the first half of the week (on either Monday, Tuesday, or Wednesday), in the restudy it was found that 32.4 percent of all arrivals occurred during this "earlier" part of the week. This finding is very likely related to two facts: the inclusion of the Labor Day and Easter weekends in the sampling in the first study, and the growing number of retirees using the Toledo Bend facility.

Table 9.—Day of arrival at Toledo Bend of users sampled in 1971 and 1974

	Restudy (1974)		First study (1971)	
Day of arrival	No. of groups	Percent	No. of groups	Percent
Sunday	29	6.7	49	8.1
Monday	47	10.8	40	6.6
Tuesday	46	10.6	18	3.0
Wednesday	48	11.0	23	3.8
Thursday	41	9.4	63	10.4
Friday	129	29.7	238	39.3
Saturday	70	16.1	136	22.5
No response	25	5.7	38	6.3
Total	435*	100.0	605	100.0

*There was one missing value excluded from the restudy totals.

Length of Stay

How many days persons said they had stayed or would stay at Toledo Bend is shown in Table 10. The number of days shown in this table includes the day of arrival and the day of departure. In the original study, the most frequently reported time of stay was 3 days; however, in the restudy the most frequently reported period of stay was 2 days, with slightly over one-fifth (22.9 percent) of the people indicating they could not afford to be away from their jobs or homes for a longer period. This was considerably more than the 14.7 percent who had indicated a stay

Table 10.—Length of stay at Toledo Bend of users sampled in 1971 and 1974

Number of days*	Restudy (1974)		First study (1971)	
	No. of groups	Percent	No. of groups	Percent
1	74	17.0	50	8.3
2	100	22.9	89	14.7
3	85	19.5	184	30.4
4	47	10.8	135	22.3
5	38	6.4	40	6.6
6	13	3.0	20	3.3
7	29	6.7	24	4.9
8	4	0.9	14	2.3
9	4	0.9	7	1.2
10-20	24	5.5	24	4.0
21+	21	4.8	11	1.7
No response	7	1.6	7	1.2
Total	436	100.0	605	100.0

*Includes day of arrival and departure.

of 2 days at the time of the original study. Almost as large a number of those interviewed in the follow-up study (19.5 percent) planned a stay of 3 days. Also, more persons reported they were at Toledo Bend for only 1 day in 1974 (17 percent) than did in 1971 (8.3 percent), and fewer reported they were planning a stay of 4 days (10.8 percent as compared with 22.3 percent). All in all, it is clear that there is a change in the patterns of usage which is in keeping with the drop in fish productivity and the type of development which has taken place.

Nature of Trip

As can be seen in Table 11, most of the people interviewed said the nature of their Toledo Bend visit was a vacation of some kind. In fact, there were considerably more vacationists than were found 3 years earlier. About 17 percent of the interviewees indicated they were on their major annual vacation, while another 23.6 percent described their visit as made during one of several shorter vacations they took during the year. It is interesting to note that only 22.5 percent of the interviewees in the first study indicated they were on a vacation of some kind.

As in the first study, a frequently cited response regarding the nature of the trip was that the fishing group had taken advantage of a weekend or other overnight trip during time off from work. Some 31.2 percent of the interviewees in the restudy described their trips as falling in such time periods.

Table 11.—Nature of trips as reported by Toledo Bend users sampled in 1971 and 1974

Nature of trip	Restudy (1974) No. of groups	Restudy (1974) Percent	First study (1971) No. of groups	First study (1971) Percent
Major annual vacation	72	16.5	43	7.1
One of several shorter vacations	103	23.6	93	15.4
Weekend or overnight trip	136	31.2	258	42.6
Day-off trip	44	10.1	49	8.1
Holiday outing	2	0.5	123	20.3
Combined business and pleasure	7	1.6	5	0.8
Combined visit to relatives and friends	8	1.8	18	3.0
Live or work at Toledo Bend	0	0.0	4	0.7
Retired (spent frequent long stays)	0	0.0	6	1.0
Not specified	5	1.2		
Total	436	100.0	605	100.0

One of the expected findings relative to nature of trip was the change in the percentage of users who were on a holiday outing. One-fifth of the interviewees in the original study said they were on a holiday vacation but only two of the interviewees in the restudy described their trip to Toledo Bend as of this type. This finding was due to the fact that interviews were taken on the Labor Day and Easter weekends in the first study but no holiday occurred during the time of the second study. Holidays have traditionally been viewed as opportunities for families and other groups to engage in fishing or other outings.

Boats and Motors Transported to Toledo Bend

In the restudy about three-fourths (76.3 percent) of all respondents reported the presence of one or more boats in their group. Practically all of these respondents (73.6 percent) said only one boat was brought by their party; less than 3 percent were with groups which had brought two or more boats. The number of boats brought per recreation group to Toledo Bend at the time of the first study and at the time of the restudy is shown in Table 12. It can be seen that there was a relatively large increase in the number of recreational groups bringing boats. This trend can again be related to a change in the type of fishing being done. Certain types of fishing, i.e., fishing for crappie (sac-a-lait) and blue gill (bream), have slackened off or deteriorated due to the growth cycle of the lake, but bass fishing has held up or improved. A larger number of boats is in keeping with the bass clubs which have begun to flourish in the Toledo Bend area. The reservoir still enjoys a reputation for being one of the best bass fishing lakes in the country.

Table 12.—Number of boats brought per group by Toledo Bend users sampled in 1971 and 1974

Number of boats brought per group	Restudy (1974)			First study (1971)		
	No. of groups	Percent	Total no. of boats	No. of groups	Percent	Total no. of boats
One	321	73.6	321	349	57.8	349
Two	11	2.5	22	32	5.3	64
Three or more	1	0.2	3	8	1.3	32
No boat in group	103	23.7		213	35.1	
No response	—	——		3	0.5	
Total	436	100.0	346	605	100.0	445

At the time of the restudy the most common type of boat brought by users was a fiberglass "bass" rig (see Table 13). Eight of every 10 boats (81.5 percent) brought to the lake were of this type in 1974, whereas less than half the boats brought by users in 1971 were of this type. The second most popular boat at the time of the restudy was still the jon-boat (commonly called "bateau" or "flat" or "skiff"). However, this type boat accounted for only 13.6 percent of those brought to Toledo Bend by users questioned, compared with 33.5 percent in 1971. It can be seen from these findings that the large majority of boats brought to Toledo Bend were types which represent a considerable investment of money.

As was expected on the basis of findings of the first study, most users brought outboard motors with them to Toledo Bend. Four-fifths (80.7 percent) of the respondents said someone in their group had brought a motor. In the first Toledo Bend study the comparable figure was 84.9 percent, indicating that more boats than motors were rented at that time.

Table 13.—Types of boats used by Toledo Bend users sampled in 1971 and 1974

Type of boat	Restudy (1974)		First study (1971)	
	No. of boats	Percent of all boats	No. of boats	Percent of all boats
Aluminum jon-boat or skiff	47	13.6	149	33.5
Bass rig (14 ft. or less)	41	11.8	67	15.1
Bass rig (over 14 ft.)	241	69.7	140	31.5
Ski rig (14 ft. or more)	6	1.7	48	17.5
Other or not specified	11	3.2	11	2.5
Total	346	100.0	445	100.0

Table 14 was prepared to show the number and percentage of the user groups reporting one, two, or three or more motors at the time of the original and restudy periods.

Table 14.—Number of outboard motors brought per group by Toledo Bend users sampled in 1971 and 1974

No. of motors in group	Restudy (1974) No. of groups	Restudy (1974) % of all groups	Restudy (1974) Total no. of motors	First study (1971) No. of groups	First study (1971) % of all groups	First study (1971) Total no. of motors
1	340	78.0	340	459	75.8	459
2	11	2.5	22	43	7.1	86
3+	1	0.2	3	12	2.0	46
None	83	19.1		82	13.6	
No response	1	0.2		9	1.5	
Total	436	100.0	365	605	100.0	591

Recreation Activities

It was a bit surprising at the time of the restudy to find that as many as 93.1 percent of the respondents said fishing was the principal activity engaged in by their group (see Table 15). Of the 436 users interviewed, only 30 reported they had not come to fish. It had been expected that a larger percentage would have a principal interest in camping, swimming, sailing, or hiking.

These activities were participated in, but to a much lesser extent than fishing. Aproximately 23 percent of the respondents indicated swimming was engaged in by at least one member of their parties and about 10 percent of the respondents said someone in their groups participated in skiing. Boating for pleasure was reported by approximately one-tenth (9.9

Table 15.—Principal types of activities engaged in by Toledo Bend users sampled in 1974

Principal types of activities	Respondents Number	Respondents Percent
Fishing	406	93.1
Camping	119	27.2
Swimming	99	22.7
Picnicking	50	11.5
Skiing	43	9.9
Boating	43	9.9
Sightseeing	23	5.3
Hunting	18	4.1
Hiking	17	3.9
Wilderness experience	17	3.9
Other	26	6.0

percent) of the interviewees. Camping was mentioned by 27.2 percent of the respondents and picnicking was reported by 11.5 percent. Unfortunately, comparable data were not obtained at the time of the first study.

Expenditures for Toledo Bend Expeditions

Table 16 includes findings with respect to trip costs reported by respondents. About half (47.1 percent) of those interviewed at the time of the restudy said they spent $49 or less. Approximately one of every five respondents reported spending more than $50 but less than $100 for their trip. With the exception of one respondent, who said he spent about $1,000 for this trip, the remainder of the respondents said they spent between $100 and $500. As can be seen in Table 17, approximately four of every five persons said the expense incurred was typical of the amount they usually spent for a trip to Toledo Bend. An examination of Tables 16 and 17 shows the similarity of findings relative to expenditures between the original study and the restudy of Toledo Bend users.

Table 16.—Trip costs reported by Toledo Bend users sampled in 1971 and 1974

Cost in dollars	Restudy (1974)		First study (1971)	
	No. of persons	Percent	No. of persons	Percent
Under 10	17	3.9	31	5.1
10-19	61	14.0	64	10.6
20-29	67	15.4	102	16.9
30-39	38	8.7	82	13.6
40-49	22	5.1	54	8.9
50-74	72	16.5	116	19.2
75-99	21	4.8	27	4.5
100-500	127	29.2	113	18.7
500+	1	0.2	0	0.0
No response	10	2.2	16	2.5
Total	436	100.0	605	100.0

Table 17.—Responses to question on whether costs reported were typical for a trip to Toledo Bend

Responses	Restudy (1974)		First study (1971)	
	No. of persons	Percent	No. of persons	Percent
Yes	350	80.3	446	73.7
No, usually more	28	6.4	23	3.8
No, usually less	18	4.1	51	8.4
Don't know	36	8.3	50	8.3
No response	4	0.9	35	5.8
Total	436	100.0	605	100.0

Group Nature of Recreation Experience: 1974 Restudy

Size of Party

Tables 18 and 19 were prepared to show the group nature of recreational activity at Toledo Bend. It can be seen in these tables that group or party sizes varied considerably. In 1974, 42 persons (9.6 percent of the 436 persons interviewed) reported they were fishing alone. In 1971 only 10 of 605 respondents (1.7 percent) had reported being alone. The modal

Table 18.—Sizes of groups of Toledo Bend users sampled in 1971 and 1974

No. of persons in group	Restudy (1974) Frequency of occurence	Restudy (1974) Percent	First study (1971) Frequency of occurrence	First study (1971) Percent
1	42	9.6	10	1.7
2	132	30.3	146	24.1
3	77	17.7	73	12.1
4	66	15.1	86	14.2
5	36	8.3	80	13.2
6	26	6.0	62	10.3
7	13	3.0	34	5.6
8	18	4.1	26	4.3
9	5	1.1	20	3.3
10	8	1.8	20	3.3
11-15	10	2.3	39	6.5
16-30	3	.7	9	1.4
Total	436	100.0	605	100.0

Table 19.—Characteristics of Toledo Bend user groups sampled in 1971 and 1974

Type of group	Restudy (1974) No.	Restudy (1974) Percent	First study (1971) No.	First study (1971) Percent
Single family with no chlidren	79	18.1	88	14.5
Single family with children	118	27.1	146	24.1
Two or more families	69	15.8	186	30.7
Family plus friends or relatives	44	10.0	76	12.6
Group of friends	57	13.1	78	12.9
One person alone	0	0.0	10	1.7
Organized group	38	8.7	1	.2
Other	29	6.7	18	3.0
No information	2	.5	2	.3
Total	436	100.0	605	100.0

size of Toledo Bend user groups was the two-person group in both 1971 and 1974; however, relatively speaking, there were more such groups in 1974 than in 1971. The size of restudy groups ranged up to 19 persons, but most groups (87 percent) did not consist of more than six persons. The median size of Toledo Bend parties in the restudy was 3.5, versus a median size group of four persons in the original study. It may be concluded from this finding that fishing is being done more by two fishing partners than by family groups.

Types of Groups

The characteristics of the user groups are presented in Table 19. The data presented indicate that at Toledo Bend recreation continues to be a popular family affair, although organized fishing groups are becoming more numerous. The findings of the restudy show that families composed of a husband and wife, with or without children, comprised 197 (45.2 percent) of the 436 parties represented. In 1971, such family groups made up 38.6 percent of the fishing parties sampled. At the time of the restudy, 69 parties (15.8 percent) were made up of two or more families and an additional 44 parties (10 percent) were composed of a single family plus one or more friends or relatives. At the time of the first study, 30.7 percent of the fishing groups were made up of two or more families and 12.6 percent of the groups included friends and relatives as well as family members. Groups of friends made up about one-eighth of the parties sampled for both the first and second study. An interesting difference in the nature of fishing parties encountered at the two time intervals is found in the number of formally organized parties. While there were virtually no such parties reported in 1971, almost 10 percent of the fishing groups sampled in 1974 were of this nature. This phenomenon is no doubt related to the increase in the number of bass clubs and other fishing clubs and in sponsored tourist activity.

Assessment of Current Problems and Needed Improvements by Marina Owners and Managers and Other Knowledgeables

In 1971, at the time of the first study of Toledo Bend users, the persons interviewed were asked to identify the problems and needed improvements they saw as users of the facility. Heading the list of things considered to need improvement were roads, boat launching sites, campsites, and grounds. At the time the second study was being planned, the matter of a need to determine continuing problems and felt needs for improvement was again a major consideration. After some deliberation, it was decided that it would be more meaningful to get the opinions of highly knowledgeable persons on these matters. It was thus decided to hold in-depth, unstructured interviews with as many marina owners and managers and others more or less permanently associated with Toledo Bend operations as possible. During the week that the field work for the restudy was in progress some 28 such individuals were interviewed. While the interviews conducted were not truly random, they represented about half of the marinas in actual operation. Care was taken to assure that representation was obtained from owners and managers of sites all along the Louisiana shoreline; interviews were obtained from individuals located along the northern, middle, and southern parts of the reservoir. Only two individuals refused to participate in the study.

In viewing the comments obtained from marina owners/managers in answer to questions about the problems of Toledo Bend and needed improvement there, the reader should be aware that they spoke from the standpoint of their interests and experience. Obviously, they derive their livelihood from their operations and are sensitive to factors they feel reduce the returns from these operations. The problems and/or needed improvements mentioned are listed below in the order of the frequency with which they were mentioned.

Leasing of State Park Sites to Private Operators: Over three-fourths of the marina operators interviewed felt it was unfair to private marina owners for the state to lease already developed park sites to their competitors. Their complaints, in essence, were that public funds had been used to develop the sites, and that the improvements there gave the leaseholder/concessionaire an economic advantage.

Lack of Communication with and Cooperation from Local Governing Authorities: Forty-six percent of the respondents complained that local and state agencies and authorities were not cooperating adequately in maintenance or improvement of facilities vital to the operation of marinas. Problems involving such things as roads, littering, dislodged buoys, floating debris, and vandalism were cited as the responsibility, at least in part, of public agencies. It should be made clear that in this instance the emphasis was on getting support for improvements themselves.

Need for More and Better Roads: Inadequate roads were cited as a problem by 43 percent of the respondents. In commenting on the need for better roads, a number of the marina owners and managers expressed the feeling that local governing bodies had failed to meet their responsibilities for construction and maintenance. Sentiment was to the effect that more attention had been paid to roads leading to state-operated sites.

Need for Channel and Boat Lane Markers: A need for channel and boat lane markers was mentioned by 42.9 percent of the respondents, about the same relative number that called for better roads. As time has gone by, the original markers have broken their moorings and floated away and the lanes marked by dead trees can no longer be found because the top parts of the trees have rotted.

Variable Water Levels: Almost two of every five respondents mentioned problems encountered because of the fluctuating water level of the lake, which they blamed on the sale of water to rice farmers. Some were having trouble because their launching areas were too shallow or dried out and others were certain the quality of fishing was affected. In situations of this type the facts may not be altogether straight, but feelings are based on genuine concern.

Decreased Fish Productivity: Over one-third of the marina operators listed poor fishing as a major problem insofar as their operations were concerned. This development has already been mentioned and was to be expected, given the usual history of reservoirs. Nevertheless, the drop in fish takes was seen as something which might be corrected with stocking of certain species, such as channel catfish and "chinquapin" (bream). It was also mentioned that better control of the water level and of hyacinth and moss would improve fishing.

Need for Clearing, Dredging, and Removal of Debris: Just less than one-third of the respondents listed the clearing and deepening of areas of the lake as needed improvements. The increasing frequency with which dead trees are falling into the water, and the need for channels to reach marinas at low water levels, were cited as two major problems. In the first instance, it was felt that areas could be blocked and protected for skiing and swimming by some sort of screen. Dredging would open once again the so-called "fingers" in the lake which have become filled because of a combination of siltation and bank erosion.

Need for a More Systematic Public Information and Relations Program: Just about one-third of the 28 respondents were convinced that a better advertising program would help the development of the area. Their feeling was that Toledo Bend had a great deal to offer the outdoor recreationist, but that too few people were aware of the facilities and opportunities there. It was implied that promotional efforts on a statewide and regional basis would help greatly and that such a campaign could be financed from the 2 percent tax they paid on the receipts from their operations.

Miscellaneous Needs and Problems: A relatively large number of other problems were mentioned by the respondents. However, since less than one-fourth of them mentioned any of these problems, they are simply listed.

1. The need for better law enforcement to control drinking, stealing, vandalism, and littering.
2. The need to patrol the lake because of speeding, conflicts between skiers and fishermen, and laxity in the practice of safety.
3. The need for more and better road signs.
4. The need for development of more picnicking, swimming, and skiing areas.
5. The need for better enforcement of fish and game limits.
6. The need for control of the use of firearms.
7. The need for better control of sanitation and other facilities designed to encourage the more discriminating user.

In concluding this brief review of the matters which marina owners and managers are concerned about, one fact is clear. There is considerable concern about what might be termed economic survival. Almost every one of the problems mentioned had something to do with the operation of marinas catering to a fishing clientele. It has been pointed out that fishing is on the decline, a fact which suggests that thought should be given to other types of facilities. Perhaps development for hiking, boating or camping enthusiasts would help solve the major problem of a decline in recreationist users.

Summary and Conclusions

It was pointed out in the introduction to this report that the purpose of the study was to monitor changes which occurred in the patterns of usage of Toledo Bend Reservoir over a 3-year period and to determine the nature of the problems which still persist. The findings of the investigation are not only revealing, but provide a basis for future planning. They may be highlighted as follows.

The authors of the study found that the type of person coming to Toledo Bend for recreation changed somewhat over the period from 1971 to 1974. Although the 1971 Toledo Bend users were found to be more affluent, better educated, and holding better jobs than the average Louisianian, 1973 users were more affluent, were more highly educated and held higher status jobs, generally speaking, than the 1971 users.

A second finding of note was that Toledo Bend users in 1974, as in 1971, tended to have rural farm or rural nonfarm early childhood experiences; however, not nearly as many of the 1974 group lived in larger cities. Why this difference was found is not clear, but it probably is related to the change in the fishing characteristics of the lake.

The third finding was that Toledo Bend users still came to the lake primarily for fishing but did not travel as far or stay as long in 1974 as they did in 1971. This change may have more than one explanation. For one thing, it is plausible to assume that the energy crisis has curtailed travel to recreation areas some distance from major urban centers. In fact, other studies bear this out. For another, there appear to be more persons who fish regularly on weekends among the current users of Toledo Bend.

A fourth finding is that the users of Toledo Bend are more apt to bring their own boats and have expensive "bass" type fishing rigs than was true of fishermen in earlier years. This finding is in keeping with the change in the character of fishing done and the growing number of persons who enjoy the "sport" aspect of fishing as contrasted to the "meat" aspect.

The fifth finding was that the average user spent more money in 1974 than was true in 1971. In this regard, it is of interest that about one-fifth of the fishing parties sampled included at least one person interested in recreational activity other than fishing. It seems there is a slow but growing interest in the swimming, skiing, camping, and boating opportunities which Toledo Bend represents.

Sixth among the findings was that users are still predominantly members of family groups. However, there is a noticeable increase in smaller groups and formally organized parties. This finding is probably related to the change in fishing productivity noted previously.

Finally, there is clear evidence that the nature of the problems perceived at Toledo Bend has changed. As the facility has aged, predictable maintenance and control problems have begun to attract attention. Such things as solid waste disposal, vandalism, the need for policing boat operators, the increase in floating debris, the loss of buoys, and the need for better control of the water level are mentioned frequently. At the same time, there is less concern over roads, telephones, and overnight accommodations—problems emphasized at the time of the first study.

The overall conclusion which emerges is that Toledo Bend Reservoir is undergoing a rather natural and expected transition. This transition is apparently associated with the appeal this facility has for different types of users. Currently, it still attracts many fishermen, but the 'bass" type of fisherman is finding it more to his liking than the less specialized and "professionalized" fisherman. Also, more nonfishermen are now found among users. The planners and developers with responsibility for Toledo Bend must be cognizant of what is happening and take the measures necessary to not only maintain but increase the level of use of this most unusual resource.

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Effects of Rate of Planting on Yield And Some Yield Components Of Sugarcane

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Introduction

The culture of sugarcane in Louisiana has been based largely on traditions developed by generations of growers rather than on research. There are many variations in cultural practices employed in the production of sugarcane. Due to increasing costs of production and shortages of farm labor, growers are interested in using the best cultural practices to produce maximum yields.

Alternate methods of planting, such as narrow row spacing and double drill planting on wide rows, have been shown to increase stalk population and yield. However, cane planted on rows other than the standard width requires the modification of equipment and is difficult to cultivate and harvest without damaging the crop.

Although the recommended rate of planting sugarcane is two stalks with a 10 percent lap, the rates vary widely among growers and locations. The rates range from two to five stalks in a continuous line on rows six feet wide. Varieties which produce low plant populations are usually planted at higher rates. Also, soil areas which consistently produce low plant populations and yields are usually planted at higher rates.

In view of the wide variations in rates of planting now used and the problems involved with alternate methods of planting, more research has been needed on rates of planting. Also, the development of new varieties and better cultural practices has created the need for testing rates of planting to increase yields.

The objective of this study was to determine the effects of several rates of planting on the yield, stalk population, and other yield components of current sugarcane varieties at several locations in Louisiana.

Review of Literature

The planting of sugarcane in Louisiana was first described by DeBow (*5*)[2] in 1846 as a process in which three cane stalks were laid in a row at a distance of four inches apart. In 1900, Stubbs (*16*) described the planting of sugarcane as involving the opening of a furrow in the center of the row with a double moldboard plow, depositing two to four continuous lines of cane into the furrow, and covering the cane with soil using a cultivator.

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[2] Italic numbers in parentheses refer to Literature Cited, Page 28.

Hebert (*7*) reported that whole stalks were used for planting in Louisiana, whereas in other countries, discarded portions of stalks, cane tops, or short stalk pieces were used satisfactorily. He found that planting two stalks with a lap was more beneficial than planting two stalks or one-and-a-half stalks without a lap. Arceneaux (*2*) found that by using small seed pieces instead of whole stalks, yield was reduced because of cane rot. He obtained a slight increase in yield of sugar per ton of cane, but not in yield of cane per acre by increasing the rate of planting from two to three stalks. Matherne (*13*) reported that increasing planting rates often gave higher early plant populations, but that competition during the growing season eliminated most of the added shoots. These increased plant populations were accompanied by a corresponding decrease in stalk weight. The increase in yield by planting three and four stalks over the normal two-stalk rate was not significant.

Dillewijn (*6*) found that 25 percent of the stalk population at harvest was primary shoots, and that increasing the planting rate increased the initial number of shoots but not necessarily the millable stalk populations. Bains (*3*) in Calcutta found that seed rates of 30,000 to 35,000 setts produced higher yields than 25,000 setts per acre. Boyce (*4*) in Pangola found that the planting of excessive seed cane to insure maximum yields was justified under most conditions. Thompson (*17*) in Natal reported that the only real disadvantage to planting higher rates for maximum stalk number was the cost of the seed cane. Mathur and Singh (*14*) in India found that an increase in planting rate increased the number of tillers and millable cane, especially in low tillering varieties.

Matherne (*12*) obtained significant increases in stalk population by planting two drills on six-foot rows. Williams and Forte (*20*) reported that the mortality rate of the early shoots was higher with double drill than single drill planting, but not high enough to offset the significantly higher plant population and cane yield obtained with the double drill planting. Matherne (*11*) reported that significantly higher plant populations and cane yield were obtained by reducing the row width from six to three feet. He found that the cane on narrow rows was very difficult to cultivate and harvest.

Humbert (*9*) stated that sugarcane varieties have a very important role in determining the optimum row spacing or plant population to produce high yields. He also reported that stalks produced on narrow rows were smaller in diameter and lighter than those produced on wider spaced rows, and row widths of less than five feet were not economical.

Abbott (*1*) emphasized the importance of vigorous germination and production of good initial stands or populations of cane rather than the amount of seed cane required for planting. He pointed out that it was important to use a high quality cane for planting and that poor germination was due largely to disease, insect, and mechanical damage to the seed cane.

Varma (*19*) in India obtained a significant positive correlation between cane yield and percent germination, cane height, and number of stalks. Cane yield was not associated with the number of tillers per plant or the diameter of stalks. Legendre (*10*) and Matherne (*11*) found a significant positive correlation between cane yield and number of stalks per acre. They also found a positive association between sugar yield and number of stalks per acre.

Experimental Procedure

Seven experiments were conducted at four locations to determine the effects of rates of planting on the yield and some of the yield components of sugarcane varieties in Louisiana.

The experiments were conducted on the locations, soil types and in the years shown in Table 1. The experiments were numbered according to the soil type and cane varieties tested rather than chronologically by years. Experiment 1 was with plant cane in 1971 and Experiment 2 was with plant cane in 1972 and first stubble cane in 1973. Experiments 3 and 4 were with plant cane in 1973 and 1974, respectively. Experiment 5 was with plant cane in 1973. Experiment 6 was with plant cane in 1971 and Experiment 7 was with plant cane in 1972 and first stubble in 1973. All the experiments were conducted on silt loam soils except Experiment 5, which was conducted on a silty clay loam soil.

The rates of planting tested in each experiment were two, three, and four stalks. A two-plus-two rate was also included in the St. Gabriel

Table 1.–Location, soil type, and year of experiments

Experiment number	Location	Soil type	Year conducted
1	Alma Plantation	Commerce sil	1971
2	St. Gabriel Station	Commerce sil	1972-73
3	St. Gabriel Station	Commerce sil	1973
4	St. Gabriel Station	Commerce sil	1974
5	Woodlawn Plantation	Mhoon sicl	1973
6	Allain Plantation	Jeanerette sil	1971
7	Allain Plantation	Jeanerette sil	1972-73

experiments. This was a different method of planting the four-stalk rate in which two stalks were planted in two drills 12 inches apart on each row. The other rates were planted in one drill on each row. The rate of planting refers to the number of cane stalks planted in a continuous line with a 10 percent overlap in rows six feet wide.

The cane varieties in Experiments 1 through 5 on Commerce and Mhoon soils were CP 48-103, L 60-25, CP 61-37, and L 62-96. The varieties in Experiments 6 and 7 on Jeanerette soil were CP 52-68, L 60-25, CP 61-37, and L 62-96. The varieties were chosen according to their adaptation to the soil type at each location. Each rate of planting was tested with four varieties in factorial experiments using a randomized block design with three or four replications. The plots were three rows wide and from 35 to 60 feet long:

The cane in each experiment was harvested at a normal harvest time, usually in November for stubble cane and in December for plant cane. The cane yield on each plot, except in Experiments 2 and 3, was obtained by weighing the cane with tractor-mounted scales. In these two exceptions, the yield was calculated by multiplying the average stalk weight by the number of millable stalks. This method of measuring yield was described by Hebert (*8*).

A 10-stalk sample from each plot was crushed at harvest time with a sample mill for juice analysis. Percent brix in the cane juice was determined with a brix hydrometer, standardized at 20 degrees Centigrade. Polariscope readings of the juice were made with a Bausch and Lomb polariscope using the lead subacetate method described by Meade (*15*). Percent sucrose in the juice was obtained from conversion tables (*15*) using the percent brix and polariscope readings. The percent brix and sucrose were converted to normal juice brix and sucrose values using mill factors from a commercial sugar mill. Sugar yield per ton of cane was determined in accordance with the data published annually by the U.S. Department of Agriculture on sugar commercially recoverable from sugarcane (*18*). Sugar yield per acre was calculated from the sugar per ton and cane yield per acre.

The yield components measured were stalk number, weight, length, and diameter. Plant population counts were made during the first week of each month during the growing season in four of the experiments. All the shoots were counted from April through August and only the millable stalks were counted in September and October. The average stalk weight, length, and diameter were determined at harvest time in two of the experiments. A 40-stalk sample from each plot was used to make these determinations.

Results and Discussion

The cane and sugar yield data obtained in the seven experiments on rates of planting are presented in Tables 2, 3, and 4. The plant population data are presented as means in Table 5 and in detail in Appendix Tables 9 through 14. The data on stalk weight, length, and diameter are reported as means in Tables 6 and 7 and in detail in Appendix Tables 15 and 16. Simple correlation coefficients between some of the variables are shown in Table 8. A factorial analysis of the data from each experiment showed that there were no significant interactions between varieties and rates of planting. Therefore, the mean effects of rates are included in the discussion.

Cane and Sugar Yield

The yield data obtained in Experiments 1 through 5 on Commerce and Mhoon soils are reported in Table 2.

Results obtained with plant cane at Alma Plantation in Experiment 1 show the variety CP 48-103 produced a significantly lower yield with the two-stalk than with the four-stalk rate. The yields produced with varieties L 60-25 and L 62-96 were lower with the two-stalk than with the other rates. The yield with CP 61-37 was lower with the two-stalk than with the three-stalk rate.

The yield data obtained with plant cane at the St. Gabriel Experiment Station in Experiment 2 show that the cane yield produced with variety CP 48-103 was significantly lower with the two-stalk rate than with the other rates tested. Variety L 60-25 produced a lower cane yield with the two-stalk and four-stalk rates than with the two-plus-two rate. A lower cane yield was obtained with the two-stalk rate than with the four-stalk and two-plus-two stalk rates with variety CP 61-37. Variety L 62-96 produced a lower cane yield with the two-stalk rate than with the three-stalk rate. The data obtained with first stubble cane in Experiment 2 show that variety L 60-25 produced a lower cane yield with the two-stalk rate than with the three-stalk and two-plus-two rates. The cane yield produced with variety L 62-96 was lower with the two-stalk rate than with the four and two-plus-two rates.

The data obtained with plant cane at St. Gabriel in Experiment 3 show that varieties L 60-25 and L 62-96 produced lower cane yields with the two-stalk rate than with the four and two-plus-two rates. For both varieties, the three-stalk rate produced lower cane yields than the two-plus--two rate. The cane yield produced with variety CP 61-37 was lower with the two-stalk rate than with the two-plus-two rate.

Results from the plant cane at St. Gabriel in Experiment 4 indicate that the cane yields produced with varieties CP 48-103 and L 60-25 were significantly lower with the two-stalk rate than with the four and the two-plus-two rates. Variety L 62-96 produced a lower cane yield with the two-stalk rate than with the other rates tested. Varieties CP 48-103 and L 62-96 produced a lower cane yield with the three-stalk rate than with the two-plus-two rate.

Table 2.—Effects of rate of planting on the yield of four varieties of sugarcane in five experiments on Commerce and Mhoon soils

Rate of planting1/	Cane yield of varieties				Mean yield		
	CP 48-103	L 60-25	CP 61-37	L 62-96	Cane	Sucrose	Sugar
(stalks)	(tons/a)				(tons/a)	%	(lb./a)
			Plant cane, Exp. 1, Alma				
2	24.2	26.3	30.1	23.7	26.1	14.0	5207
3	26.1	29.7	34.1	29.1	29.7	14.0	5976
4	27.4	30.0	31.4	30.4	29.8	14.5	6243
LSD (.05)	3.0				1.5		302
			Plant cane, Exp. 2, St. Gabriel				
2	38.9	42.1	42.6	42.5	41.5	12.9	7537
3	44.0	45.8	45.6	47.2	45.6	13.4	8631
4	44.9	44.7	47.0	46.1	45.7	13.0	8353
2 + 2	44.6	48.8	50.5	45.0	47.2	13.1	8627
LSD (.05)	3.9				1.9		353
			Stubble cane, Exp. 2, St. Gabriel				
2	35.0	33.2	36.1	30.1	33.6	13.1	6144
3	36.4	37.0	37.5	32.6	35.9	13.2	6636
4	35.8	36.2	36.4	34.0	35.6	13.1	6517
2 + 2	38.0	36.5	39.1	34.8	37.1	12.7	6523
LSD (.05)	3.2				1.6		311

(Continued)

Table 2.–(Continued)

Rate of planting[1] (stalks)	Cane yield of varieties				Mean yield		
	CP 48-103	L 60-25	CP 61-37	L 62-96	Cane	Sucrose	Sugar
	-----------	-----------	(tons/a)	-----------	-----------	%	(lb./a)
			Plant cane, Exp. 3, St. Gabriel				
2	35.3	40.5	39.7	40.9	39.1	12.6	6912
3	37.5	44.0	43.2	43.0	41.9	13.0	7675
4	38.3	45.8	42.4	45.0	42.9	13.1	7902
2 + 2	38.1	49.2	44.1	47.4	44.7	12.9	8123
LSD (.05)	----------	-----3.6-----	----------	----------	1.8		386
			Plant cane, Exp. 4, St. Gabriel				
2	36.7	35.4	30.9	30.1	33.3	14.0	6617
3	37.7	37.3	31.5	33.1	34.9	14.2	7056
4	39.9	39.8	31.3	34.8	36.4	13.9	7236
2 + 2	41.9	39.1	31.8	36.0	37.2	13.9	7354
LSD (.05)	----------	-----2.9-----	----------	----------	1.4		284
			Plant cane, Exp. 5, Woodlawn				
2	26.8	27.7	30.9	26.1	27.9	14.7	5875
3	28.0	28.7	34.8	28.0	29.9	14.9	6412
4	29.0	31.2	34.1	29.1	30.8	15.0	6705
LSD (.05)	----------	-----2.6-----	----------	----------	1.5		326

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[1] The 2 + 2 rate is 2 stalks in 2 drills planted 12 inches apart.

Results obtained with plant cane at Woodlawn Plantation in Experiment 5 show that lower cane yields were produced with varieties L 60-25 and L 62-96 with the two-stalk rate than with the four-stalk rate. Variety CP 61-37 produced a lower cane yield with the two-stalk rate than with the three-stalk and four-stalk rates.

The yield data obtained in Experiments 6 and 7 on Jeanerette soil at Allain Plantation are reported in Table 3. Results with plant cane in Experiment 6 indicate that variety CP 52-68 produced a lower yield with the three-stalk than with the four-stalk rate. The yields produced with variety CP 61-37 were lower with the two- and three-stalk rates than with the four-stalk rate. Variety CP 62-96 produced less with the two-stalk rate than with three- and four-stalk rates.

Results with plant cane in Experiment 7 indicate that the cane yield produced with variety CP 61-37 was significantly lower with the two-stalk rate than with the three-stalk rate. Variety L 62-96 produced a lower yield with the two-stalk rate than with the three-stalk and four-stalk rates. Data from the first stubble cane in Experiment 7 indicate that variety CP 61-37 produced a lower cane yield with the two-stalk rate than with the three-stalk and four-stalk rates. The differences in cane yields due to the rate of planting were small with the other varieties.

The differences in cane yields between the rates of planting as an average of varieties in each experiment are presented in Table 4. The two-stalk rate produced a significantly lower cane yield than the three-stalk rate in six out of seven experiments, with an average difference of 2.3 tons per acre. The two-stalk rate produced a significantly lower cane yield than the four-stalk rate in all the experiments, with an average difference of 2.8 tons per acre. The three-stalk rate produced a significantly lower cane yield than the four-stalk rate in two of the experiments, with an average difference of 0.5 ton. In the three experiments in which the two-plus-two rate was tested, it produced a significantly higher cane yield than the four-stalk rate in one experiment, with an average increase of 1.4 tons. The two-plus-two rate produced a significantly higher cane yield than the two-stalk rate in each of the three experiments, with an average increase of 4.7 tons. This increase was due to the combined effect of increasing the planting rate and using the double drill method of planting.

The rate of planting did not significantly affect the percent sucrose in the normal juice of the varieties in each experiment. Therefore, the effects of rate of planting on the sugar yields were similar to those on the cane yields except for the small differences in the sugar yield in Experiment 7. The increases in the cane and sugar yields due to increasing the planting rate were more pronounced on the Commerce and Mhoon soils than on the Jeanerette soil and more with plant cane than with stubble cane.

Table 3.—Effects of rate of planting on the yield of four varieties of sugarcane in two experiments on Jeanerette soil

Rate of planting (stalks)	Cane yield of varieties				Mean yield		
	CP 52-68	L 60-25	CP 61-37	L 62-96	Cane	Sucrose	Sugar
	----------	----------	(tons/a)	----------	----------	%	(lb./a)
			Plant cane, Exp. 6, Allain				
2	29.1	33.3	35.6	30.6	32.1	13.6	6230
3	28.4	33.5	35.5	33.9	32.8	13.7	6431
4	31.1	32.0	39.5	34.3	34.2	13.8	6735
LSD (.05)	----------	2.4	----------	----------	1.2		230
			Plant cane, Exp. 7, Allain				
2	34.5	32.3	38.8	31.9	34.4	14.2	7003
3	34.4	32.6	41.8	37.3	36.5	13.9	7233
4	35.6	34.4	41.0	35.8	36.7	13.6	7070
LSD (.05)	----------	2.5	----------	----------	1.5		NS
			Stubble cane, Exp. 7, Allain				
2	22.8	21.2	26.9	23.4	23.6	14.3	4844
3	21.8	23.2	29.0	25.7	24.9	14.0	4980
4	22.3	22.1	29.3	25.2	24.7	14.2	4984
LSD (.05)	----------	2.1	----------	----------	1.2		NS

Table 4.—Differences in cane yield between rates of planting as an average of varieties in each experiment

Rate of planting		Experiment number and yield differences[1]									
Lower	Higher	1P	2P	2S	3P	4P	5P	6P	7P	7S	Mean
(stalks)		tons cane/A.									
2	3	3.6*	4.1*	2.3*	2.8*	1.6*	2.0*	0.7	2.1*	1.3*	2.3
2	4	3.7*	4.2*	2.0*	3.8*	3.1*	2.9*	2.1*	2.3*	1.1	2.8
3	4	0.1	0.1	-0.3	1.0	1.5*	0.9	1.4*	0.2	-0.2	0.5
2	2 + 2	-	5.7*	3.5*	5.6*	3.9*	-	-	-	-	4.7
3	2 + 2	-	1.6	1.2	2.8*	2.3*	-	-	-	-	2.0
4	2 + 2	-	1.5	1.5	1.8*	0.8	-	-	-	-	1.4

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[1] The yield differences represent the increases in cane yield due to increasing the rate of planting from a lower to a higher rate. P is for plant cane and S is for first stubble cane.

*Significant at the .05 level of probability.

Plant Population

The plant population data obtained in Experiments 2, 3, 5, and 7 are reported as means in Table 5 and in detail for each variety in Appendix Tables 9 through 14. The total number of shoots or plants per acre are reported monthly from April to August and only the number of millable stalks are reported in September and October.

The data in Table 5 show that the plant population in each experiment increased with each increase in the rate of planting during the growing season. However, the increases were considerably larger in the total plant population early than in the number of millable stalks late in the season.

The data obtained in Experiment 2 at St. Gabriel indicate that the number of millable stalks produced with the two-stalk rate was lower than with the two-plus-two rate in the stubble cane.

Results with plant cane in Experiment 3 at St. Gabriel indicate that the millable stalk population in October with the two-stalk rate was lower than with the four-stalk rate. The stalk population with the two-plus-two rate was higher than with the other rates. This was the only experiment in which the two-plus-two rate produced significantly more millable stalks and cane yield than the four-stalk rate.

The data obtained with plant cane in Experiment 5 at Woodlawn Plantation show that the two-stalk rate produced a lower number of millable stalks than the four-stalk rate. The relatively low plant population obtained during the entire season at this location was probably due to poor weed control.

The data obtained in Experiment 7 at Allain indicate that the number of millable stalks in October with the two-stalk rate was lower than with the other rates in stubble cane but not in plant cane. The plant population in the stubble cane was unusually low, especially early in the growing season. It is not normal for plant cane to respond less to rates of planting and have a higher plant population than stubble cane. This was probably due to a poor rainfall distribution and is probably the reason that the differences in the sugar yield were unusually small at this location.

The plant population of all varieties increased rapidly during April and May to a maximum in June or July and decreased until October. This decrease was due to the dying of the weaker plants from plant competition, leaving only the millable stalks at harvest time. The plant population during the entire growing season was higher with variety L 60-25 and lower with variety L 62-96 than the other varieties tested (Appendix Tables 9-14).

Table 5.—Mean effect of rate of planting on the plant population in four of the experiments

Rate of planting (stalks)	Plant population[1/]						
	April	May	June	July	Aug.	Sept.	Oct.
	(1000/acre)						
Plant cane, Exp. 2, St. Gabriel							
2	13.9	30.7	51.0	67.6	56.7	34.9	
3	18.6	37.2	58.8	76.1	63.6	37.2	
4	22.7	41.6	64.2	81.6	66.1	38.5	
2 + 2	28.3	51.4	73.1	85.6	71.4	39.2	
LSD (.05)	3.1	4.9	6.4	4.8	4.5	1.6	
Stubble cane, Exp. 2, St. Gabriel							
2	52.1	61.1	71.7	65.6	41.1	40.1	35.5
3	56.5	67.4	75.1	69.2	41.2	40.2	36.3
4	63.7	75.9	83.9	72.3	43.0	42.3	36.9
2 + 2	67.7	80.3	88.3	74.1	44.6	43.3	38.5
LSD (.05)	6.7	7.9	5.2	4.6	1.9	2.1	2.2
Plant cane, Exp. 3, St. Gabriel							
2	11.5	23.7	53.6	55.9	38.1	35.9	33.1
3	14.7	23.3	60.8	58.9	41.2	37.6	34.5
4	19.1	27.1	71.4	65.9	42.8	38.9	35.6
2 + 2	21.0	30.8	80.3	69.1	44.6	40.6	37.4
LSD (.05)	1.7	6.0	4.9	3.7	2.2	1.5	1.5

(Continued)

Table 5.—(Continued)

Rate of planting (stalks)	Plant population[1/]						
	April	May	June	July	Aug.	Sept.	Oct.
	------------	------------	------------	(1000/acre)	------------	------------	------------
			Plant cane, Exp. 5, Woodlawn				
2	12.7	15.1	34.3	45.9	38.8	28.1	25.6
3	17.1	20.6	43.6	51.2	41.2	28.9	26.4
4	21.2	25.0	44.6	53.6	41.4	30.5	28.2
LSD (.05)	2.1	2.4	4.5	4.0	2.6	1.7	2.1
			Plant cane, Exp. 7, Allain				
2	25.0	31.2	59.2	66.2	50.5	33.6	30.8
3	28.0	33.8	64.2	69.8	53.6	34.0	32.3
4	31.0	37.7	67.5	72.2	57.0	35.3	32.6
LSD (.05)	2.3	2.9	4.3	2.4	4.7	NS	NS
			Stubble cane, Exp. 7, Allain				
2	27.0	28.8	34.2	40.4	30.3	29.0	26.1
3	30.0	32.3	37.5	44.1	32.0	30.3	28.1
4	32.0	34.5	40.2	44.5	32.0	32.0	28.7
LSD (.05)	4.2	4.7	4.6	NS	NS	1.8	1.9

[1/] Average of four varieties.

Stalk Weight, Length, and Diameter

The data obtained on stalk size in Experiments 2 and 3 at the St. Gabriel Station are reported as means in Tables 6 and 7 and in detail for each variety in Appendix Tables 15 and 16. The rates of planting had no significant effects on the stalk weight, length, or diameter. The stalk weight decreased from plant to stubble cane for all varieties and rates of planting. The stalk weight, length, and diameter were largest in variety L 62-96 and smallest in variety L 60-25. Varieties CP 48-103 and CP 61-37 produced similar stalk sizes.

Correlations

Correlation coefficients between rate of planting, cane yield, and the yield components in four of the experiments are reported in Table 8. The degree of association between rate of planting and plant population decreased progressively during the growing season. This was apparently due to the more pronounced effect of rate of planting on the total plant population early than on the millable stalk number late in the season.

Significant positive correlations were obtained between the rate of planting and cane yield and between cane yield and the number of millable stalks in all experiments except one. However, the correlations between rate of planting and number of millable stalks were not significant. Generally, significant negative correlations were obtained between plant population and stalk weight, length, and diameter.

The correlations indicate that there was an unknown factor affecting the cane yield and millable stalk population during a short period of time late in the growing season. This was indicated by the higher correlations between cane yield and millable stalk population than the correlations between rate of planting and millable stalk population. The effect could possibly be due to gaps in the stand of cane within plots. As reported by Arceneaux (*2*), it is important to obtain a uniform germination of seed cane to produce a high yield. Excessive tillering can produce a high shoot population with a gappy stand. However, these shoots do not necessarily develop into millable stalks due to plant competition.

Summary and Conclusions

Experiments were conducted at several locations in Louisiana to determine the effects of rate of planting on yield and some of the yield components of sugarcane. The rates of planting tested were two, three, four, and two-plus-two stalks in a continuous line with a 10 percent overlap in rows six feet wide. The two-plus-two rate was two stalks in two drills planted 12 inches apart on each row. The other rates were planted in one drill on each row. Each rate was tested with four commercial varieties of sugarcane.

Table 6.—Mean effect of rate of planting on stalk weight, length, and diameter of plant and first stubble cane in Experiment 2 at the St. Gabriel Station

Rate of planting (stalks)	Plant cane stalk weight (lb.)	First stubble cane stalk weight (lb.)	First stubble cane stalk length (ft.)	First stubble cane stalk diameter (mm)
2	2.41	1.93	7.3	24.8
3	2.48	1.98	7.3	25.0
4	2.41	1.96	7.2	24.0
2 + 2	2.43	1.96	7.3	24.5
LSD (.05)	NS	NS	NS	NS

Table 7.—Mean effect of rate of planting on stalk weight, length, and diameter of plant cane in Experiment 3 at the St. Gabriel Station

Rate of planting (stalks)	Stalk weight (lb.)	Stalk length (ft.)	Stalk diameter (mm)
2	2.38	8.2	26.2
3	2.44	8.4	26.1
4	2.43	8.3	25.9
2 + 2	2.42	8.2	26.0
LSD (.05)	NS	NS	NS

Table 8.—Correlation coefficients between rate of planting, cane yield and some yield components in four of the experiments

	Plant population			Cane yield
	April	July	Oct.	
	Plant cane, Experiment 2, St. Gabriel			
Rate of planting	.66	.46	.32	.54
Cane yield	.53	.35	.40	-
Millable stalk weight	-.32	-.56	-.72	.22
	Stubble cane, Experiment 2, St. Gabriel			
Rate of planting	.27	.19	.11	.33
Cane yield	.58	.56	.73	-
Millable stalk weight	-.77	-.77	-.86	-.43
Millable stalk length	-.69	-.66	-.70	-.27
Millable stalk diameter	-.73	-.65	-.66	-.33
	Plant cane, Experiment 3, St. Gabriel			
Rate of planting	.72	.47	.28	.43
Cane yield	.49	.30	.50	-
Millable stalk weight	-.15	-.50	-.58	.31
Millable stalk length	.06	-.25	-.25	.39
Millable stalk diameter	-.36	-.40	-.33	-.03
	Plant cane, Experiment 5, Woodlawn			
Rate of planting	.54	.30	.24	.37
Cane yield	.34	.61	.49	-
	Plant cane, Experiment 7, Allain			
Rate of planting	.24	.19	.17	.28
Cane yield	-.24	-.24	.15	-
	Stubble cane, Experiment 7, Allain			
Rate of planting	.28	.17	.23	.14
Cane yield	.58	.38	.48	-

r value required for significance at 5% = .33.

The interaction between varieties and rate of planting was small in the yield and yield component data obtained in each experiment. As an average of varieties in seven experiments conducted, the two-stalk rate produced a significantly lower cane yield than the three-stalk rate in six experiments. The two-stalk rate produced a lower yield than the four-stalk rate in all the experiments. The differences in the cane yield between the three-stalk and four-stalk rates were not significant.

The rate of planting did not affect the percent sucrose in the cane juice and increases in sugar yields were similar to increases in cane yields. The increases in yield were more pronounced on Commerce and Mhoon soils than on Jeanerette soil. In the two experiments in which first stubble data were obtained, the increases in yield were more pronounced with plant cane than with stubble cane.

In four experiments in which the plant population was studied, the two-stalk rate produced a significantly lower number of millable stalks than the three-stalk rate in two of the experiments and a lower number than the four-stalk rate in three of the experiments. The differences in the number of millable stalks between the three-stalk and four-stalk rates were small. The two-plus-two rate produced a significantly higher number of millable stalks and a significantly higher cane yield than the four-stalk rate in one out of three experiments in which it was tested.

The plant population of all varieties increased rapidly during April and May to a maximum in June or July, then decreased until October. The increases due to rate of planting were considerably larger in the total plant population early in the growing season than in the number of millable stalks in October. The rate of planting had no significant effect on stalk weight, length, and diameter.

A significant positive correlation was obtained between rate of planting and cane yield and between cane yield and the number of millable stalks in all experiments except one. The correlations between rate of planting and the number of millable stalks were not significant. These relationships indicate that there was an unknown factor affecting the cane yield and number of millable stalks. Significant negative correlations were obtained between the number of millable stalks and stalk weight, length, and diameter.

This study indicates that sugarcane yields can be increased with the current varieties with rates of planting higher than the recommended two-stalk rate. The increases in yield were consistent but relatively small and may not be profitable due to the increase in the cost of seed cane and labor required to plant higher rates. However, these increases were obtained with a high quality seed cane under good germinating conditions. A three-stalk rate could be profitable when planting a low quality seed cane under poor germinating conditions, especially with low tillering varieties.

APPENDIX

Table 9.—Effect of rate of planting on the plant population of four varieties of plant cane in Experiment 2 on Commerce silt loam soil at the St. Gabriel Experiment Station, Iberville Parish, 1972

Variety of cane	Rate of planting (stalks)	Plant population April	May	June	July	Aug.	Sept.
		(1000/acre)					
CP 48-103	2	12.6	25.3	49.5	74.9	59.3	33.8
	3	16.9	32.6	56.6	89.6	71.1	37.3
	4	21.8	37.6	60.4	90.1	71.0	37.9
	2 + 2	27.2	46.1	74.6	94.6	79.7	38.6
	Mean	19.6	35.4	60.3	87.3	70.3	36.9
L 60-25	2	17.6	34.8	67.2	68.2	63.1	38.6
	3	23.2	41.8	76.2	75.5	69.2	40.5
	4	29.0	48.8	88.6	83.4	76.2	43.4
	2 + 2	35.3	57.5	99.8	90.8	80.3	43.8
	Mean	26.3	45.7	82.9	79.5	72.2	41.6
CP 61-37	2	13.0	34.4	50.4	73.5	53.7	38.0
	3	17.8	40.6	53.8	79.3	55.9	39.6
	4	20.2	44.8	64.2	87.2	59.3	41.0
	2 + 2	26.7	57.3	68.9	88.7	64.0	42.7
	Mean	19.4	44.3	59.3	82.2	58.2	40.4
L 62-96	2	12.4	28.1	36.8	53.9	50.9	29.2
	3	16.5	33.6	48.6	60.2	58.3	31.3
	4	19.9	35.1	43.6	65.6	57.9	31.6
	2 + 2	23.9	44.5	49.2	68.3	61.7	31.8
	Mean	18.2	35.3	44.6	62.0	57.2	31.0
LSD (.05) for treatment		6.3	9.8	12.8	9.6	8.9	3.2
LSD (.05) for means		3.1	4.9	6.4	4.8	4.5	1.6

Table 10.—Effect of rate of planting on the plant population of four varieties of first stubble cane in Experiment 2 on Commerce silt loam soil at the St. Gabriel Experiment Station, Iberville Parish, 1973

Variety of cane	Rate of planting (stalks)	Plant population						
		April	May	June	July	Aug.	Sept.	Oct.
		(1000/acre)						
CP 48-103	2	52.0	58.7	77.8	75.8	41.2	40.2	36.7
	3	58.3	69.3	79.2	77.7	41.3	40.2	36.7
	4	61.7	73.2	84.0	79.6	42.0	40.8	36.3
	2 + 2	73.8	85.6	93.7	83.0	45.0	44.3	39.0
	Mean	61.4	71.7	83.7	79.0	43.4	41.4	37.2
L 60-25	2	69.8	84.8	98.7	78.7	47.9	47.5	41.3
	3	69.2	88.9	99.4	81.2	46.7	46.3	41.4
	4	93.0	115.7	115.8	90.6	51.4	50.6	43.9
	2 + 2	93.9	120.0	123.5	94.1	53.4	52.1	45.4
	Mean	81.5	102.4	109.3	86.2	49.9	49.1	43.0
CP 61-37	2	51.7	66.6	69.9	63.1	44.9	42.8	37.5
	3	59.7	67.7	73.5	68.2	44.0	42.2	39.0
	4	63.0	74.5	81.8	69.6	44.5	43.8	37.7
	2 + 2	61.1	70.0	81.0	66.6	45.2	44.2	38.9
	Mean	60.2	69.7	76.6	66.9	44.6	43.2	38.3
L 62-96	2	29.7	34.1	40.3	44.7	30.4	30.0	26.5
	3	38.9	43.7	48.4	49.8	32.8	32.0	27.9
	4	37.1	40.0	53.9	49.5	34.2	34.1	29.9
	2 + 2	41.8	45.6	54.8	52.5	35.0	32.7	30.8
	Mean	36.9	40.9	49.4	49.1	33.1	32.2	28.8
LSD (.05) for treatment		11.5	15.9	10.4	9.2	3.8	4.3	4.3
LSD (.05) for means		6.7	7.9	5.2	4.6	1.9	2.1	2.2

Table 11.—Effect of rate of planting on the plant population of four varieties of plant cane in Experiment 3 on Commerce silt loam soil at the St. Gabriel Experiment Station, Iberville Parish, 1973

Variety of cane	Rate of planting (stalks)	Plant population April	May	June	July	Aug.	Sept.	Oct.
		------------------------	------------------------	------------------------	(1000/acre)	------------------------	------------------------	------------------------
CP 48-103	2	12.0	16.2	48.5	54.1	36.6	34.0	31.7
	3	14.5	19.7	60.9	59.9	40.8	35.6	33.8
	4	19.6	26.8	68.4	66.0	39.9	36.5	34.0
	2 + 2	22.3	35.4	74.1	68.2	39.7	37.2	34.5
	Mean	17.1	24.5	63.0	62.0	39.2	35.9	33.5
L 60-25	2	14.2	33.8	68.8	65.6	41.6	38.6	37.2
	3	17.0	32.7	74.4	64.5	42.3	40.7	38.2
	4	24.0	36.8	97.4	77.8	45.3	42.7	41.0
	2 + 2	26.8	42.0	107.2	84.8	48.1	45.9	44.5
	Mean	20.5	36.3	87.0	73.2	44.3	42.0	40.2
CP 61-37	2	9.8	24.2	49.4	58.8	42.9	40.3	34.6
	3	12.6	23.2	57.1	57.7	49.8	41.9	35.9
	4	14.8	21.3	60.7	60.5	51.5	42.6	36.0
	2 + 2	17.6	23.5	76.5	66.0	55.1	44.5	37.7
	Mean	13.7	23.1	60.9	60.8	49.8	42.3	36.0
L 62-96	2	10.1	20.6	47.7	45.3	31.3	30.8	29.0
	3	14.5	17.6	50.7	53.5	31.7	31.9	30.2
	4	18.1	23.6	59.0	59.4	34.6	33.5	31.5
	2 + 2	17.2	22.2	63.2	57.3	35.5	34.6	32.6
	Mean	15.0	21.0	55.2	53.9	33.3	32.7	30.8
LSD (.05) for treatment		3.5	11.9	9.8	7.4	4.4	2.9	3.1
LSD (.05) for means		1.7	6.0	4.9	3.7	2.2	1.5	1.5

Table 12.—Effect of rate of planting on the plant population of four varieties of plant cane in Experiment 5 on Mhoon silty clay loam soil at Woodlawn Plantation, Assumption Parish, 1973

Variety of cane	Rate of planting (stalks)	Plant population April	May	June	July	Aug.	Sept.	Oct.
		(1000/acre)						
CP 48-103	2	8.9	11.4	24.3	40.5	33.7	24.2	22.4
	3	11.9	14.0	30.4	44.7	34.9	23.6	22.8
	4	15.0	19.3	34.0	48.5	37.7	27.0	25.9
	Mean	11.9	14.9	29.6	44.6	35.4	24.9	23.4
L 60-25	2	15.9	19.4	37.3	49.8	45.4	30.0	28.2
	3	24.9	30.9	54.9	60.4	50.6	34.3	31.9
	4	30.5	37.8	57.6	63.5	50.5	35.6	32.1
	Mean	23.8	29.4	49.9	57.9	48.8	33.3	30.7
CP 61-37	2	16.0	18.8	49.1	58.2	44.6	34.3	30.3
	3	18.2	23.5	59.2	60.2	46.8	32.9	30.1
	4	21.9	25.4	55.4	60.9	46.2	33.9	29.2
	Mean	18.7	22.6	54.5	59.7	45.9	33.7	29.8
L 62-96	2	9.9	10.7	26.7	35.1	31.6	24.2	21.4
	3	13.2	13.8	30.1	39.6	32.2	24.8	21.8
	4	17.2	17.5	31.5	41.6	31.2	25.3	25.8
	Mean	13.4	14.0	29.4	38.8	31.7	24.8	23.0
LSD (.05) for treatment		3.6	4.2	7.8	6.9	4.5	3.0	3.6
LSD (.05) for means		2.1	2.4	4.5	4.0	2.6	1.7	2.1

Table 13.—Effect of rate of planting on the plant population of four varieties of plant cane in Experiment 7 on Jeanerette silt loam soil at A. V. Allain Plantation, St. Mary Parish, 1972

Variety of cane	Rate of planting (stalks)	Plant population April	May	June	July	Aug.	Sept.	Oct.
		(1000/acre)						
CP 52-68	2	18.4	27.7	51.9	68.6	47.0	31.5	29.3
	3	17.9	22.9	52.6	67.1	48.7	29.0	28.3
	4	19.2	27.7	56.3	69.5	49.7	31.6	30.6
	Mean	18.5	26.1	53.6	68.4	48.5	30.7	29.4
L 60-25	2	39.1	41.0	81.6	80.9	60.4	38.3	36.6
	3	45.0	47.3	87.4	88.0	63.9	40.0	37.4
	4	41.2	51.6	90.1	95.2	69.9	40.1	36.6
	Mean	43.8	46.6	86.3	88.0	64.8	39.5	36.9
CP 61-37	2	21.2	31.2	53.8	62.3	46.4	33.4	31.7
	3	24.7	35.8	62.8	68.8	52.9	36.2	35.8
	4	29.5	40.5	68.5	66.0	56.2	39.1	35.4
	Mean	25.1	35.9	61.7	65.7	51.8	36.2	34.3
L 62-96	2	21.2	24.7	49.4	52.9	48.0	31.3	25.5
	3	24.2	29.1	53.9	55.0	48.9	30.7	27.7
	4	28.2	30.9	55.0	58.2	52.1	30.3	28.0
	Mean	24.5	28.2	52.8	55.4	49.7	30.8	27.1
LSD (.05) for treatment		4.0	5.1	7.4	4.1	8.2	3.5	3.3
LSD (.05) for means		2.3	2.9	4.3	2.4	4.7	2.0	1.9

Table 14.—Effect of rate of planting on the plant population of four varieties of first stubble cane in Experiment 7 on Jeanerette silt loam soil at A. V. Allain Plantation, St. Mary Parish, 1973

Variety of cane	Rate of planting (stalks)	Plant population						
		April	May	June	July	Aug.	Sept.	Oct.
		(1000/acre)						
CP 52-68	2	22.7	22.9	27.8	35.9	26.9	24.9	21.0
	3	25.1	26.6	29.3	35.7	27.3	25.2	24.4
	4	25.3	25.6	29.0	32.8	26.4	27.8	24.2
	Mean	24.4	25.1	28.7	34.8	26.8	26.0	23.2
L 60-25	2	31.4	35.6	43.5	46.8	34.3	32.7	30.4
	3	33.1	37.4	47.4	55.6	35.8	34.4	31.8
	4	32.1	38.6	50.2	56.8	35.7	35.5	32.1
	Mean	32.2	37.2	47.1	53.1	34.9	34.2	31.4
CP 61-37	2	27.2	29.3	35.8	46.0	33.4	32.3	29.3
	3	30.4	31.1	38.8	47.8	37.4	34.8	31.0
	4	36.5	38.3	43.7	51.6	38.0	37.2	33.5
	Mean	31.4	33.6	39.4	48.5	36.2	34.8	31.3
L 62-96	2	26.6	27.4	29.7	32.8	26.9	26.2	23.9
	3	31.3	31.9	34.5	37.3	28.7	26.8	25.2
	4	34.1	35.5	38.0	36.8	28.0	27.7	25.1
	Mean	30.7	31.6	34.1	35.6	27.9	26.9	24.7
LSD (.05) for treatment		7.2	8.2	7.9	8.1	5.0	3.1	3.3
LSD (.05) for means		4.2	4.7	4.6	4.7	2.9	1.8	1.9

Table 15.—Effect of rate of planting on stalk weight, length, and diameter of plant and first stubble cane in Experiment 2 on Commerce silt loam soil at the St. Gabriel Experiment Station, Iberville Parish, 1972-73

Variety of cane	Rate of planting (stalks)	Plant cane stalk wt. (lb.)	First stubble cane stalk wt. (lb.)	First stubble cane stalk length (ft.)	First stubble cane stalk diameter (mm)
CP 48-103	2	2.30	1.91	7.0	23.9
	3	2.36	1.98	7.2	25.5
	4	2.37	1.97	7.4	24.8
	2 + 2	2.30	1.95	7.6	24.9
	Mean	2.33	1.95	7.3	24.8
L 60-25	2	2.18	1.61	6.6	23.2
	3	2.26	1.67	6.9	23.2
	4	2.06	1.65	6.4	22.3
	2 + 2	2.23	1.61	6.6	22.6
	Mean	2.18	1.64	6.6	22.8
CP 61-37	2	2.24	1.92	7.7	26.2
	3	2.30	1.92	7.0	24.9
	4	2.29	1.93	7.0	22.8
	2 + 2	2.36	2.01	7.4	25.2
	Mean	2.30	1.95	7.3	24.8
L 62-96	2	2.91	2.27	7.7	25.8
	3	3.01	2.33	8.0	26.2
	4	2.92	2.28	7.8	26.2
	2 + 2	2.83	2.26	7.6	25.1
	Mean	2.92	2.29	7.8	25.8
LSD (.05) for treatment		0.20	0.17	0.8	1.5
LSD (.05) for means		0.12	0.08	0.4	1.0

Table 16.—Effect of rate of planting on stalk weight, length, and diameter of plant cane in Experiment 3 on Commerce silt loam soil at the St. Gabriel Experiment Station, Iberville Parish, 1973

Variety of cane	Rate of planting (stalks)	Stalk weight (lb.)	Stalk length (ft.)	Stalk diameter (mm)
CP 48-103	2	2.23	8.0	24.5
	3	2.22	7.6	25.9
	4	2.25	8.1	26.3
	2 + 2	2.21	7.9	25.5
	Mean	2.23	7.9	25.6
L 60-25	2	2.18	8.2	25.0
	3	2.30	8.3	25.9
	4	2.23	8.4	25.0
	2 + 2	2.21	8.0	25.1
	Mean	2.23	8.2	25.3
CP 61-37	2	2.30	7.7	28.0
	3	2.41	8.5	25.7
	4	2.36	8.0	26.5
	2 + 2	2.34	7.8	27.5
	Mean	2.35	8.0	26.9
L 62-96	2	2.82	8.9	27.4
	3	2.84	9.1	26.7
	4	2.86	8.7	25.8
	2 + 2	2.91	8.9	25.8
	Mean	2.86	8.9	26.4
LSD (.05) for treatment		0.24	0.7	1.5
LSD (.05) for means		0.15	0.3	0.8

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Response of Four Corn Hybrids To Different Plant Densities and Row Spacings on Olivier Soil

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INTRODUCTION

Corn (*Zea mays* L.) is produced on a limited acreage in Louisiana, largely because the production of corn in comparison with soybeans, cotton, rice, and sugarcane has returned fewer dollars per acre to the farmers. Grain utilization in the state greatly exceeds total production, and there is a substantial potential for an expanded acreage of corn for both grain and silage in Louisiana.

Research has been conducted in the state on the effects of levels of applied nitrogen and population density on yields of corn hybrids expressed as grain and silage (*2,8,9,10*).[8] However, modern corn hybrids have not been studied in Louisiana under varying row-spacing conditions.

The study reported here was conducted to measure the response of four locally adapted corn hybrids to different plant populations and row spacings without irrigation on an Olivier silt loam soil. The three-year experiment was conducted at the Perkins Road Farm, Baton Rouge, from 1971 through 1973.

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[8] Italic numbers in parentheses refer to items in Literature Cited, Page 27.

REVIEW OF LITERATURE

Several researchers (*2,8,9,10*) in Louisiana have reported on the effect of plant population and levels of applied nitrogen on the grain and silage yields of corn (*Zea mays* L.) hybrids. Generally, hybrids responded to a population density of 20,000 plants and to applied nitrogen levels of 120 to 200 pounds per acre. Reduced ear size and prolificacy accompanied increases in population in all studies in Louisiana. Optimum populations for corn production over a wide area extending from the southeastern section to the northern plains of the United States and into Canada have been reported as being from 16,000 to 29,000 plants per acre, depending on environment (*1,5,6,7,11,13*).

Colville (*4*), in 1966, stated that yield of corn could be increased 5 percent by reducing row width from 40 to 30 inches, and another 5 percent increase could be realized by a further reduction of row width to 20 inches. Alessi et al. (*1*) found no effect of row width on grain yield in North Dakota. Nunez and Kamprath (*11*) reported that row width affected hybrid performance in North Carolina only under drought stress, in which case a 20-inch row was better than a 40-inch row. Brown et al. (*3*), in Georgia, observed that one corn hybrid responded to narrow rows, while another did not. Cummins and Dobson (*5*), working in Georgia also, found that yield increased when row width decreased in the Piedmont plains region, but row width had no effect on yield at higher elevations.

Stickler (*13*) reported greater yields in rows spaced 20 inches than at 40 inches, with little effect of irrigation on hybrid performance at the two row spacings in Kansas. In Virginia (*7*) and in Canada (*6*) yield superiorities for the 16- over the 40-inch row and for the 18- over the 36-inch row were reported, respectively. Stivers et al. (*14*) compared 20-, 30-, and 40-inch rows at several locations in Indiana and found that corn yields in the narrower row widths exceeded that of the 40-inch row by 4 to 7 percent. Shubeck and Young (*12*) reported equidistant spacing of corn plants to be effective in increasing yield at populations up to 18,000 plants per acre.

EXPERIMENTAL PROCEDURE

A three-factor experiment with four replications was conducted using a split-split-plot in a randomized block design on Olivier silt loam at the Perkins Road Farm near Baton Rouge, 1971-73. The treatment factors included four corn (*Zea mays* L.) hybrids, three row spacings of 40.0, 26.6, and 20.0 inches, and four proposed populations of 15,000, 20,000, 25,000, and 30,000 plants per acre.

Main plots were occupied by corn hybrids. Three full-season hybrids (Coker S 48, Funk's G-4949, and Pioneer brand 3147) and one medium-early season hybrid (Funk's G-4761) were used. Split-plots contained the three row spacings. Each split-plot was subdivided to accommodate the four plant populations. The sub-sub plots were 48 feet in length and 13.3 feet in width. There were four, six, and eight rows per plot for the 40.0-, 26.6-, and 20.0-inch row widths, respectively.

The experimental area was uniformly fertilized each spring with 800 pounds of 12-12-12 plus 350 pounds of ammonium nitrate. All fertilizer was broadcast pre-plant and disced into the soil. The soil surface was smoothed with a harrow and planted flat.

Planting rates were excessive; the plots were hand thinned after emergence in an attempt to obtain the desired populations. However, final stands averaged from 91 to 95 percent of the desired populations at the various planting rates, with stands of the hybrid Coker S 48 being most deficient.

Plantings were made April 7 and 8 in 1971, April 18 and 19 in 1972, and May 10 and 11 in 1973. The 1973 planting was delayed because of excessive soil moisture resulting from high rainfall levels throughout the months of March and April that year.

Immediately after planting, a broadcast treatment of 2 pounds of Atrazine 80 W plus 1 quart of Lasso per acre was applied to the soil surface. Weed control was rated fair to good; mechanical cultivation was not practiced in the plots.

A two-crop rotational system was employed so that corn followed soybeans in the rotation.

Records were collected annually on pollen-shed and silking dates, plant and ear heights, and stand count. Husked ear corn was hand harvested from interior rows of each plot—two center, three interior, and four center rows of the 40.0-, 26.6-, and 20.0-inch row widths, respectively. In all cases the harvested plot area was 0.00735 acre in size.

Total ear weight, with husks removed, and total ear count were determined for each harvested plot. Moisture content of the grain was measured and shelling percentage of the corn was obtained. Calculations were made to determine average ear weight and yield of grain adjusted to 15.5 percent moisture. Grain yields are expressed in bushels per acre.

The time of harvest each year was determined by two factors. Firstly, harvest was delayed until grain moisture was below 30 percent, and secondly, the availability of hand labor governed when harvest was begun.

All data were evaluated using analyses of variance and covariance analyses to measure statistical differences. Correlations were obtained to estimate levels of association among plant and ear characteristics and population density.

RESULTS AND DISCUSSION

I. Statistical Differences Among Treatment Combinations

Shown in Table 1 is a listing of all analyses of variance and sources of variation for plant variables evaluated, with the level of significance reported.

Year effects were significant ($P<.05$) for all variables except stalk lodging. Hybrids differed significantly in yield, plant and ear heights, ear weight, grain shelling percent, and number of days from planting to pollen shed and silk emergence. Significant row spacing effects occurred in the variables of plant erectness, stalk lodging, plant height, and number of days to flowering. Population density significantly affected yield, stalk lodging, prolificacy, ear weight, grain shelling percent, and number of days to pollen shed and silk emergence.

There were no significant ($P<.05$) first order interactions between hybrids and row spacings when data were averaged over populations. First order interactions which were significant between hybrids and populations included yield, plant erectness, stalk lodging, and ear weight. Ear number was significantly affected by the row spacing × population interaction. The only significant second order interaction involved yield.

All variables except stalk lodging were significantly influenced by years, as shown in Table 2. Mean yield was highest in 1971 and lowest in 1973. Rainfall was rather limited in 1973 during the development stages of the corn crop. From May 12 through July 15 of 1973 a total of 3.67 inches of rainfall was recorded, as compared with 8.38 and 11.73 inches for that period in 1971 and 1972, respectively. The expression of yield components—ear number and ear size—was significantly restricted during the growing season of 1973. Mean population density was significantly lower in 1973 than it was in the two prior years.

As noted in the section "Experimental Procedure," the four desired populations of 15,000, 20,000, 25,000, and 30,000 plants per acre were not realized in the field. Actual stand counts were obtained and recorded for all plots each year of the study. Tabular data involving plant population as a variable carry, under the column heading of treatment, the four desired populations. However, actual plant numbers per acre are reported in each table, also, and the actual populations, rather than the desired populations, are referred to in discussion of the results.

Means for hybrids, row spacings, and population densities are reported in Table 3. Hybrids differed significantly in all plant and ear characteristics except plant erectness, ear number, and grain moisture level at harvest. In addition, Coker S 48 was the only hybrid with a lower mean population density. Consequently, the expression of yield potential by Coker S 48 could have been unfavorably biased by the low population, in comparison with the other hybrids.

Table 1.—Levels of statistical significance from analysis of variance of variables studied

	Source of Variation							
Variable	Year	Hybrid	Row spacing	Hybrid x row	Plant pop	Hybrid x pop	Row x pop	Hybrid x row x pop
Yield	**[1]	**	NS[2]	NS	**	*[3]	NS	*
Erect plts	*	NS	*	NS	NS	**	NS	NS
Stalk lodg plts	NS	NS	**	NS	**	**	NS	NS
Plt ht	**	**	**	NS	NS	NS	NS	NS
Ear ht	**	**	NS	NS	NS	NS	NS	NS
Ears/100 plts	**	NS	NS	NS	**	NS	*	NS
Ear wt	**	*	NS	NS	**	**	NS	NS
Grain shell, %	**	**	NS	NS	**	NS	NS	NS
Grain moist, %	**	NS	NS	NS	NS	NS	NS	NS
Wt/bu	**	NS	NS	NS	NS	NS	NS	NS
Days/½ poll	**	**	**	NS	*	NS	NS	NS
Days/½ silk	**	**	**	NS	**	NS	NS	NS

[1] Denotes significance at the 0.01 level of probability.

[2] Denotes nonsignificance.

[3] Denotes significance at the 0.05 level of probability.

Table 2.—Year means averaged over hybrids, row spacings, and population densities, Baton Rouge, 1971-73

Year	Yield, bu/a	Erect plts, %	Stalk lodged plts,%	Plt ht, ft	Ear ht, ft	Ears/100 plts	Ear wt, lb	Grain shell, %	Grain moist, %	Days to ½ poll	Days to ½ silk	Plts/a, 1,000
1971	116	96	3	6.6	3.4	98	.374	84	19.6	68	69	21.7
1972	100	90	6	5.9	2.9	95	.354	83	22.5	68	69	21.1
1973	43	99	1	5.4	2.8	68	.185	81	16.5	60	63	19.5
L.S.D. (.05)	8	5	NS	0.2	0.2	10	.034	1	1.9	1	1	1.3

Table 3.—Mean performance of hybrids, row spacings, and population densities on Olivier silt loam at Baton Rouge, 1971-73

Treatment	Yield, bu/a	Erect plts, %	Plt ht, ft	Ear ht, ft	Ears/100 plts	Ear wt, lb	Grain shell, %	Grain moist, %	Days to ½ poll	Days to ½ silk	Plts/a, 1,000
Hybrid[1]											
Coker S 48	74	91	6.2	3.0	89	.292	81	19.0	65	66	18.5
Funk's G-4761	89	98	5.4	2.7	83	.301	85	19.0	63	64	21.5
Funk's G-4949	80	98	6.1	3.2	88	.278	81	21.1	68	70	21.2
Pioneer brand 3147	102	92	6.1	3.2	89	.378	84	19.1	66	67	21.8
Row spacing, ins[2]											
40.0	86	96	6.0	3.0	86	.310	83	19.5	65	67	20.8
26.6	86	94	5.9	3.0	87	.302	83	19.6	66	67	20.6
20.0	87	94	5.9	3.0	88	.301	83	19.4	65	67	20.9
Population density,[3] plts/a, 1,000											
15	79	95	5.9	2.9	98	.352	82	19.5	65	67	14.3
20	86	95	6.0	3.0	88	.321	82	19.5	65	67	18.7
25	90	95	6.0	3.1	83	.287	83	19.4	65	67	22.7
30	90	94	6.0	3.0	79	.258	83	19.7	66	67	27.4
C.V.	7.1	3.2	3.0	11.8	5.3	8.9	1.2	4.1	0.8	0.9	5.2
[1]L.S.D. (.05)	9	NS	0.3	0.2	NS	.040	1	NS	1	2	1.5
[2]L.S.D. (.05)	NS	2	0.1	NS	NS	NS	NS	NS	1	NS	NS
[3]L.S.D. (.05)	3	NS	NS	NS	2	.012	1	NS	1	NS	-

Pioneer brand 3147, with a mean yield of 102 bushels per acre, produced significantly more grain and had larger ears than the other hybrids. Funk's G-4761 was the second highest yielder and the earliest to flower; also, it had the highest mean grain shelling percent.

The mean effects of row spacing on yield, ear height, prolificacy, ear size, grain shelling percent, grain moisture content, and number of days to silk were not significant. Neither was there a significant relationship between row spacing and mean number of plants per acre. Percentage of erect plants and plant height were greatest in 40-inch rows. Pollen-shed was earlier by one day in 40.0- and 20-inch rows than it was in 26.6-inch rows; this difference, though statistically significant, is of little practical importance.

Mean yields and grain shelling percentages at the 22,700 and 27,400 plant populations were identical and higher ($P<.05$) than those at the two lower populations. The 18,700 plant population significantly outyielded the 14,300 plant population. Each increase in population density decreased the expression of prolificacy and ear size. Mean pollen shed was delayed by one day at the highest population as compared with the other three populations. Population density had little effect on plant erectness, plant and ear heights, grain moisture at harvest, and number of days to silk emergence.

Performance records of the four hybrids at each of the three row spacings as an average of populations are shown in Table 4. Least significant differences for hybrids and row spacings interaction means are reported in Table 8. There were no significant hybrid × row spacing interactions for any of the variables studied.

Table 5 includes performance data of the hybrids at the four populations averaged over row spacings. Coker S 48 produced more grain at 23,400 plants than it did at either 13,100 or 16,800 plants per acre. Yield differences for Coker S 48 were not significant between the 13,100 and 16,800 or between the 16,800 and 20,600 plant populations. The yields of both Funk's G-4761 and Funk's G-4949 at 23,000 plants were significantly greater than at 15,000 plants, with no real differences among the other plant populations for either hybrid. Pioneer brand 3147 responded favorably in yield to the population increase from 14,700 to 19,700 plants. Yields of Pioneer brand 3147 did not differ significantly among the three highest populations.

Of three yield components, number of ears per 100 plants, ear weight, and grain shelling percent, only ear weight showed a significant hybrid × population interaction averaged over row spacings. Ear size of Coker S 48 was smaller at 23,400 than at 13,100 plants per acre. In the other three hybrids, ear weight was lowest at the highest population. A significant reduction in ear size with each increase in plant population occurred with Pioneer brand 3147.

The mean actual population of Coker S 48 was lower than those of the other hybrids at each of the three highest planting rates.

Table 4.—Response of four corn hybrids to three row spacings as an average of population densities on Olivier silt loam at Baton Rouge, 1971-73

Treatment[1]	Yield, bu/a	Erect plts, %	Stalk lodged plts, %	Plt ht, ft	Ear ht, ft	Ears/100 plts	Ear wt, lb	Grain shell, %	Grain moist, %	Days to ½ poll	Days to ½ silk
C. S48-40.0	76	92	3	6.2	2.9	88	.303	81	19.2	65	66
-26.6	73	91	4	6.1	2.8	89	.288	80	18.9	66	67
-20.0	74	90	4	6.1	3.1	89	.285	80	19.0	65	66
F. 4761-40.0	90	98	1	5.6	2.7	83	.317	86	18.8	62	64
-26.6	88	97	2	5.4	2.7	83	.309	85	19.1	63	65
-20.0	88	98	1	5.4	2.6	82	.305	85	19.2	63	64
F. 4949-40.0	79	98	1	6.2	3.3	85	.286	81	21.0	68	70
-26.6	79	98	2	6.0	3.3	88	.274	81	21.4	68	70
-20.0	83	97	1	6.1	3.2	91	.275	81	20.8	68	70
P. 3147-40.0	100	95	4	6.2	3.2	87	.335	84	19.1	65	67
-26.6	103	90	8	6.1	3.2	89	.339	84	19.2	66	67
-20.0	103	92	8	6.1	3.2	89	.339	84	18.8	66	67
C.V.	7.1	3.2	54.2	3.0	11.8	5.3	8.9	1.2	4.1	0.8	0.9

[1] Treatment identification: first series, hybrid - C. for Coker, F. for Funk's, and P. for Pioneer.

second series, row spacing in inches - 40.0, 26.6, and 20.0.

Table 5.—Response of four corn hybrids to four population densities as an average of row spacings on Olivier silt loam at Baton Rouge, 1971-73

Treatment[1]	Yield, bu/a	Erect plts, %	Stalk lodged plts, %	Plt ht, ft	Ear ht, ft	Ears/100 plts	Ear wt, lb	Grain shell, %	Grain moist, %	Days to ½ poll	Days to ½ silk	Plts/a, 1,000
C. S48-15	64	90	3	6.0	2.8	101	.308	80	18.9	65	66	13.1
-20	72	90	4	6.2	2.8	89	.304	80	18.9	65	66	16.8
-25	77	92	4	6.2	3.3	83	.280	81	18.9	65	66	20.6
-30	83	92	5	6.2	2.9	82	.275	81	19.3	65	67	23.4
F. 4761-15	83	98	1	5.5	2.7	91	.371	85	18.7	62	64	14.6
-20	88	98	1	5.5	2.7	84	.323	85	19.2	63	64	19.4
-25	93	98	1	5.4	2.6	80	.294	86	19.2	63	64	23.4
-30	91	98	1	5.4	2.7	74	.255	86	19.0	62	64	28.4
F. 4949-15	75	97	1	6.1	3.2	101	.323	81	21.1	68	70	14.7
-20	79	98	1	6.1	3.2	89	.289	80	21.1	68	70	19.1
-25	86	98	1	6.1	3.3	85	.267	81	20.5	68	70	23.0
-30	82	98	2	6.1	3.2	77	.235	81	21.5	69	71	28.3
P. 3147-15	95	96	4	6.0	3.1	99	.408	84	19.4	65	67	14.7
-20	106	93	6	6.2	3.2	90	.368	84	18.9	65	67	19.7
-25	104	93	7	6.1	3.2	84	.307	84	19.0	66	67	23.6
-30	104	88	10	6.2	3.3	81	.269	85	19.0	66	67	29.3
C.V.	7.1	3.2	54.2	3.0	11.8	5.3	8.9	1.2	4.1	0.8	0.9	5.3

[1] Treatment identification: first series, hybrid - C. for Coker, F. for Funk's, and P. for Pioneer.
second series, population density - 15-, 20-, 25-, and 30-thousand plts/a.

The only significant interaction between row spacings and plant populations, averaged for hybrids, occurred with the expression of prolificacy (Tables 6 and 8). Each increase in population with 40-inch rows resulted in a significant reduction in number of ears per 100 plants. The 26.6-inch row resulted in a significant reduction in ear number with each population increase from 14,200 to 22,200 plants, but there was no further decrease as population increased from 22,200 to 27,600 plants. In 20-inch rows, the increases in population from 14,400 to 19,000 and from 22,800 to 27,400 plants caused a significant reduction in ear number. There was no difference in ear number between 19,000 and 22,800 plants per acre at the 20-inch row spacing.

Failure to obtain the desired plant populations at the four planting rates was not associated with row spacing, as evidenced by the absence of a significant interaction for actual plant stands between row spacings and populations.

Performance data of hybrids in all possible combinations with row spacings and population densities are presented in Table 7, and levels of significance for second order interactions involving the treatment factors are reported in Table 8. Yield was the only variable exhibiting a significant second order interaction.

Coker S 48 produced its highest grain yield in 26.6-inch rows and at the maximum population level. Funk's G-4761 tended to be less sensitive to row spacing and plant population. Yields of Funk's G-4761 in combinations of 40.0-inch rows with either 23,500 or 27,600 plants, 26.6-inch rows with 19,500 plants, or 20.0-inch rows with 23,800 plants per acre did not differ, and no row-population combination of Funk's G-4761 exceeded those yields. The maximum yield of Funk's G-4949 occurred in 20.0-inch rows with 22,600 plants. Pioneer brand 3147 performed well at all of the three highest populations in certain combinations with row spacing. None of the yields significantly exceeded those of the following combinations: Pioneer brand 3147 in 40.0-inch rows and 19,700 plants, 26.6-inch rows and 19,600 plants, or 20.0-inch rows and either 23,300 or 28,800 plants per acre.

Table 6.—Effects of varying row spacings and population densities on performance as an average of hybrids on Olivier silt loam at Baton Rouge, 1971-73

Row spacing, ins	Population density, 1,000	Yield, bu/a	Erect plts, %	Plt ht, ft	Ear ht, ft	Ears/100 plts	Ear wt, lb	Grain shell, %	Grain moist, %	Days to ½ poll	Days to ½ silk	Plts/a, 1,000
40.0	15	79	96	6.0	3.0	99	.352	83	19.3	65	66	14.3
40.0	20	86	96	6.0	3.1	87	.329	82	19.7	65	67	18.7
40.0	25	90	96	6.1	3.0	83	.291	83	19.1	65	66	23.0
40.0	30	90	95	6.0	3.0	76	.269	83	20.0	65	67	27.1
26.6	15	77	96	5.9	3.0	96	.351	82	19.7	66	67	14.2
26.6	20	88	94	5.9	3.1	90	.322	82	19.7	65	67	18.5
26.6	25	86	95	5.9	3.0	82	.284	83	19.7	66	67	22.2
26.6	30	90	92	5.9	3.0	80	.252	83	19.5	66	67	27.6
20.0	15	81	95	5.8	2.9	100	.353	82	19.6	65	67	14.4
20.0	20	84	95	6.0	2.9	87	.312	82	19.2	65	67	19.0
20.0	25	93	94	6.0	3.3	85	.285	83	19.4	65	67	22.8
20.0	30	90	94	5.9	3.0	80	.255	83	19.6	66	68	27.4
	C.V.	7.1	3.2	3.0	11.8	5.3	8.9	1.2	4.1	0.8	0.9	5.2

Table 7.—Response of four corn hybrids to different row spacings and population densities on Olivier silt loam at Baton Rouge, 1971-73

Treatment[1]	Yield, bu/a	Erect plts, %	Stalk lodged plts, %	Plt ht, ft	Ear ht, ft	Ears/100 plts	Ear wt, lb	Grain shell, %	Grain moist, %	Days to ½ poll	Days to ½ silk	Plts/a, 1,000
C. S48-40.0-15	70	89	3	6.2	2.8	101	.322	81	18.5	65	66	13.7
-20	77	90	4	6.2	3.0	88	.325	80	19.4	65	66	17.2
-25	75	94	3	6.3	3.0	82	.284	82	19.0	65	66	20.2
-30	81	93	4	6.1	2.9	82	.279	81	19.8	65	66	22.6
-26.6-15	59	91	4	6.0	2.8	101	.293	79	19.1	65	66	12.6
-20	69	90	4	6.0	2.8	90	.287	80	19.0	65	67	16.1
-25	77	92	4	6.3	3.0	84	.288	81	18.6	66	67	20.0
-30	87	91	5	6.1	2.8	81	.283	81	18.8	66	67	23.9
-20.0-15	65	90	3	5.8	2.8	102	.309	78	19.1	64	66	13.2
-20	71	89	4	6.3	2.8	88	.299	80	18.3	65	66	16.9
-25	79	91	5	6.1	4.0	84	.268	81	19.1	65	66	21.6
-30	82	91	5	6.2	2.9	82	.264	81	19.4	66	67	23.6
F. 4761-40.0-15	84	98	1	5.6	2.8	93	.371	85	18.7	62	64	14.6
-20	84	97	1	5.5	2.8	83	.319	84	19.1	63	64	18.8
-25	98	98	1	5.5	2.5	82	.305	86	18.3	62	64	23.5
-30	96	97	1	5.6	2.7	75	.274	87	19.1	62	64	27.6
-26.6-15	77	98	1	5.5	2.8	89	.363	84	18.4	63	65	14.1
-20	96	97	2	5.5	2.7	87	.343	87	19.1	63	65	19.5
-25	86	97	2	5.3	2.6	77	.281	85	20.1	63	64	22.9
-30	92	97	2	5.3	2.5	77	.249	86	18.7	62	64	28.6
-20.0-15	87	98	1	5.4	2.4	92	.379	85	19.0	62	64	15.1
-20	85	98	1	5.4	2.6	83	.306	85	19.5	62	64	19.9
-25	95	98	1	5.4	2.7	81	.295	86	19.0	63	64	23.8
-30	86	98	1	5.3	2.7	71	.241	85	19.2	63	65	29.1

(Continued)

Table 7.--Response of four corn hybrids to different row spacings and population densities on Olivier silt loam at Baton Rouge, 1971-73 (Cont'd.)

	Yield, bu/a	Erect plts, %	Stalk lodged plts, %	Plt ht, ft	Ear ht, ft	Ears/100 plts	Ear wt, lb	Grain shell, %	Grain moist, %	Days to ½ poll	Days to ½ silk	Plts/a, 1,000
F. 4949-40.0-15	75	98	1	6.3	3.4	100	.331	81	20.6	67	69	14.5
-20	79	98	1	6.1	3.2	86	.301	80	21.2	68	70	19.2
-25	84	98	1	6.2	3.3	84	.268	81	20.5	68	70	23.6
-30	79	98	1	6.2	3.2	70	.245	81	21.7	68	71	28.5
-26.6-15	72	98	1	5.9	3.1	97	.321	81	21.8	68	71	14.8
-20	77	98	1	6.0	3.3	92	.279	80	21.4	68	70	18.7
-25	84	97	2	6.1	3.3	82	.268	81	20.7	69	70	22.8
-30	81	97	2	6.1	3.4	80	.226	81	21.5	69	71	28.3
-20.0-15	80	96	2	6.1	3.1	106	.316	81	20.9	68	70	14.7
-20	80	97	1	6.2	3.1	89	.286	81	20.8	68	70	19.3
-25	89	98	1	6.1	3.3	88	.265	82	20.3	68	70	22.6
-30	85	97	1	6.0	3.1	81	.232	80	21.2	69	71	28.2
P. 3147-40.0-15	89	97	3	6.1	3.1	100	.386	83	19.5	65	67	14.4
-20	106	97	3	6.3	3.2	90	.370	84	19.2	65	66	19.7
-25	101	95	4	6.2	3.1	82	.307	84	18.6	65	66	24.6
-30	102	92	7	6.2	3.3	77	.278	84	19.3	66	67	29.5
-26.6-15	101	96	4	6.1	3.1	97	.429	85	19.4	65	66	15.1
-20	111	91	9	6.0	3.3	92	.378	83	19.3	65	67	19.6
-25	99	92	9	5.9	3.2	83	.301	84	19.4	66	67	23.1
-30	100	83	10	6.2	3.3	83	.249	85	18.9	66	68	29.5
-20.0-15	94	95	5	5.9	3.1	98	.408	83	19.3	66	67	14.6
-20	100	93	7	6.2	3.2	88	.356	84	18.2	66	67	19.8
-25	110	91	8	6.3	3.2	88	.313	84	19.0	66	67	23.3
-30	109	88	11	6.1	3.3	84	.280	85	18.7	66	67	28.8
C.V.	7.1	3.2	54.2	3.0	11.8	5.3	8.9	1.2	4.1	0.8	0.9	5.2

[1] Treatment identification: first series hybrid - C. for Coker, F. for Funk's, and P. for Pioneer.
second series, row spacing in inches - 40.0, 26.6, and 20.0.

Table 8.—Least significant differences for interactions among hybrids, row spacings, and population densities, 1971-73

Interaction	Variable											
	Yield, bu/a	Erect plts, %	Stalk lodged plts, %	Plt ht, ft	Ear ht, ft	Ears/100 plts	Ear wt, lb	Grain shell, %	Grain moist, %	Days to ½ poll	Days to ½ silk	Plts/a, 1,000
Hybrid x row spacing (Table 4)	Two hybrids, one row spacing or two row spacings, one hybrid											
	L.S.D (.05)											
	NS[1]	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Hybrid x population (Table 5)	Two hybrids, one population											
	L.S.D. (.05)											
	7	6	6	NS	NS	NS	.039	NS	NS	NS	NS	1.53
	Two populations, one hybrid											
	L.S.D. (.05)											
	9	4	4	NS	NS	NS	.030	NS	NS	NS	NS	1.23
Row spacing x population (Table 6)	Two Row spacings, one population or two populations, one row spacing											
	L.S.D.											
	NS	NS	NS	NS	NS	3	NS	NS	NS	NS	NS	NS

(Continued)

Table 8.—Least significant differences for interactions among hybrids, row spacings, and population densities, 1971-73 (Cont'd.)

Interaction	Variable											
	Yield, bu/a	Erect plts, %	Stalk lodged plts, %	Plt ht, ft	Ear ht, ft	Ears/100 plts	Ear wt, lb	Grain shell, %	Grain moist, %	Days to ½ poll	Days to ½ silk	Plts/a 1,000
	Two hybrids, one row spacing, one population											
	- - - - - - - - - - - - L.S.D. (.05) - - - - - - - - - - - -											
Hybrid x row spacing x population (Table 7)	4	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Two spacings, one hybrid, one population or two populations, one hybrid, one spacing											
	- - - - - - - - - - - - L.S.D. (.05) - - - - - - - - - - - -											
	5	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[1] Nonsignificant at .05 level of probability.

2. Correlation Coefficients

Reported in Tables 9-12 are correlation coefficients showing the relationships among five yield components and the association of these components with population density for the four hybrids included in the study. Number of ears per 100 plants and ear weight were positively and strongly correlated in all four hybrids; the association apparently was closer in Coker S 48 and Funk's G-4761 than it was in Funk's G-4949 and Pioneer brand 3147. Grain shelling percent and grain moisture content at harvest were positively correlated with ear number in all hybrids. Negative correlation coefficients ($P<.01$), of approximately equal magnitude, were found between ear number and grain test weight (weight per bushel) in the four hybrids. Number of ears per 100 plants and number of plants per acre were correlated negatively in two of the four hybrids, Funk's G-4949 and Pioneer brand 3147.

Ear weight was correlated positively with both grain shelling percent and grain moisture content in all hybrids. The correlation between ear weight and test weight in all four hybrids was negative and highly significant. Pioneer brand 3147 was the only hybrid that exhibited a significant relationship between ear weight and population level; the relationship was negative.

Grain shelling percent was correlated positively with grain moisture content in three hybrids; there was no significant relationship between these two variables in the fourth hybrid, Funk's G-4949. In all hybrids grain shelling percent was correlated negatively ($P<.01$) with weight per bushel. The association between grain shelling percent and weight per bushel was strongest in Funk's G-4949. Grain shelling percent was significantly and positively correlated with number of plants per acre in three hybrids; the exception was Funk's G-4949.

Correlation coefficients of little value were found for grain moisture content with test weight and population level and for test weight with population level in all hybrids.

There were some notable differences among hybrids regarding relationships between various yield components and population density. Increases in plant population had a negative effect on the expression of prolificacy in Funk's G-4949 and Pioneer brand 3147; this effect was not expressed in Coker S 48 and Funk's G-4761. The effect of population on ear size was significant only in Pioneer brand 3147. Shelling percent was positively affected by population increases in three of the four hybrids. Plant population influenced the expression of more yield components in Pioneer brand 3147 than it did in the other hybrids.

Table 9.—Correlation coefficients among yield components of Coker S 48 corn hybrid and plant density, averaged over populations and row spacings, 1971-73

Variable	Ear wt	Shell, %	G moist, %	Wt/bu	Plts/a
Ears/100 plts	.923**	.451**	.722**	-.457**	-.272
Ear wt		.560**	.790**	-.447**	-.095
Shell, %			.393*	-.552**	.512**
G moist, %				.032	.015
Wt/bu					-.214

*,**Denotes significance at the 0.05 and 0.01 levels of probability, respectively.

Table 10.—Correlation coefficients among yield components of Funk's G-4761 corn hybrid and plant density, averaged over populations and row spacings, 1971-73

Variable	Ear wt	Shell, %	G moist, %	Wt/bu	Plts/a
Ears/100 plts	.919**	.734**	.742**	-.486**	-.170
Ear wt		.633**	.639**	-.496**	-.298
Shell, %			.674**	-.574**	.371*
G moist, %				-.125	.230
Wt/bu					-.123

*,**Denotes significance at the 0.05 and 0.01 levels of probability, respectively.

Table 11.—Correlation coefficients among yield components of Funk's G-4949 corn hybrid and plant density, averaged over populations and row spacings, 1971-73

Variable	Ear wt	Shell, %	G moist, %	Wt/bu	Plts/a
Ears/100 plts	.824**	.486**	.429**	-.453**	-.378*
Ear wt		.556**	.664**	-.456**	-.074
Shell, %			.016	-.873**	.229
G moist, %				.204	.187
Wt/bu					-.153

*,**Denotes significance at the 0.05 and 0.01 levels of probability, respectively.

Table 12.—Correlation coefficients among yield components of Pioneer brand 3147 corn hybrid and plant density, averaged over populations and row spacings, 1971-73

Variable	Ear wt	Shell, %	G moist, %	Wt/bu	Plts/a
Ears/100 plts	.869**	.518**	.677**	-.425**	-.446**
Ear wt		.628**	.762**	-.566**	-.329*
Shell, %			.627**	-.610**	.366*
G moist, %				-.209	.068
Wt/bu					-.063

*,**Denotes significance at the 0.05 and 0.01 levels of probability, respectively.

Table 13 contains all possible simple correlation coefficients involving yield, plant and ear characteristics, and number of plants per acre. The correlation coefficients were calculated over hybrids, row spacings, and populations.

Yield was correlated positively with plant density and with all plant and ear properties except plant erectness and test weight; yield was correlated negatively with the two latter variables. Yield was influenced to the greatest extent by ear size.

Negative correlations ($P<.05$) were shown for plant erectness with plant height, ear number, ear weight, grain moisture content, and number of days to mid-silk. There was essentially no relationship between plant erectness and grain shelling percent, test weight, or number of plants per acre.

The correlations between plant height and ear number, ear weight, grain shelling percent, grain moisture content, and number of days to mid-silk were positive and significant. Plant height was negatively and strongly correlated with test weight, indicating that the taller-growing hybrids had lower test weights.

Positive correlations ($P<.05$) were evidenced between number of ears per 100 plants and ear weight, grain shelling percent, grain moisture content, and number of days to mid-silk. Ear number was correlated negatively with test weight and population density.

Ear weight was correlated positively with grain shelling percent, grain moisture content, and number of days to silk emergence; in contrast, ear weight was correlated negatively with test weight and population level.

Grain shelling percent was correlated negatively with test weight and correlated positively with number of plants per acre. No significant association was detected between grain shelling percent and grain moisture content or number of days to mid-silk.

The correlation between grain moisture content and number of days to mid-silk was positive, and of considerable magnitude, as expected.

The number of days to silk emergence was negatively correlated with test weight and positively correlated with number of plants per acre.

Summarizing the simple correlation coefficients, it was noted that yield was more closely correlated with ear weight than with any of the other variables. The relationships of plant density to yield, grain shelling percent, and number of days to mid-silk were significant and positive. Plant density was associated negatively with number of ears per 100 plants and ear weight.

Table 13.—Correlation coefficients among properties of the corn plant and plant density, combining hybrids, populations, and row spacings, 1971-73

Variable	Erect plts	Plt ht	Ears/100 plts	Ear wt	Shell, %	G moist, %	Wt/bu	Days to ½ silk	Plts/a
Yield	-.337**	.677**	.677**	.831**	.690**	.593**	-.597**	.651**	.339**
Erect plts		-.197*	-.369**	-.317**	-.001	-.390**	-.152	-.376**	-.065
Plt ht			.617**	.591**	.190*	.362**	-.739**	.655**	.127
Ears/100 plts				.798**	.276**	.572**	-.443**	.681**	-.290**
Ear wt					.509**	.587**	-.484**	.565**	-.174*
Shell, %						.121	-.464**	.078	.357**
G moist, %							.013	.768**	.143
Wt/bu								-.314**	-.135
Days to ½ silk									.196*

*,**Denotes significance at the 0.05 and 0.01 levels of probability, respectively.

3. Regressions

The relationships of number of plants per acre to yield, ear number, grain shelling percent, and number of days to mid-silk were expressed by means of simple regression equations. They are shown in Figures 1-4.

As noted in Figure 1, yield increased with increases in population ($Y = 41.0491 + 2.1834X$), but only 11.47 percent of the variation in yield could be accounted for by population changes; almost 90 percent of the differences in yield were due to factors other than population level.

Increases in plant density resulted in a reduction in number of ears per 100 plants (Figure 2). The regression equation for this relationship is $Y = 105.9 - 0.9132X$. The effect of population density on the expression of prolificacy was limited, as only 8.41 percent of the variance in number of ears per 100 plants could be attributed to differences in number of plants per acre. Grain shelling percent was affected to a greater degree by population level than was ear number. As population increased, grain shelling percent increased ($Y = 78.6957 + 0.1913X$, Figure 3), with 12.8 percent of the variance in grain shelling percent being due to differences in population level.

Number of days to mid-silk was positively associated with plant population ($Y = 64.0553 + 0.1386X$, Figure 4), yet only 3.8 percent of the variation in number of days to flowering could be attributed to changes in population density.

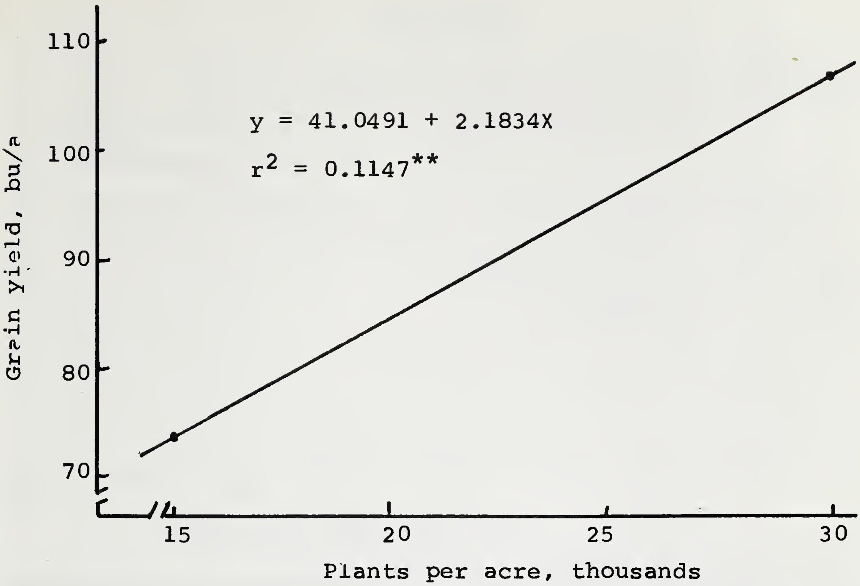

Fig. 1.—Relationship between population density and grain yield averaged over hybrids and row spacings.

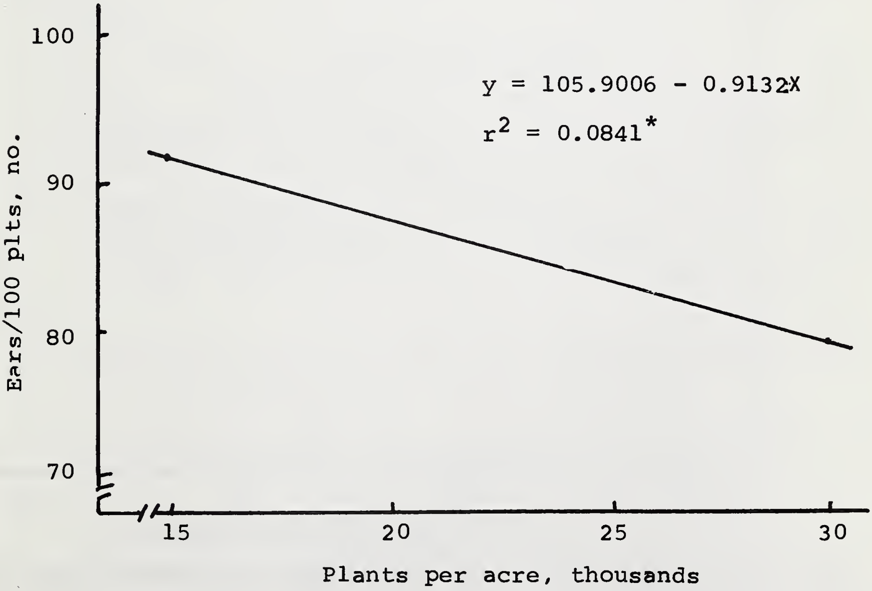

Fig. 2.—Relationship between population density and plant prolificacy in corn hybrids.

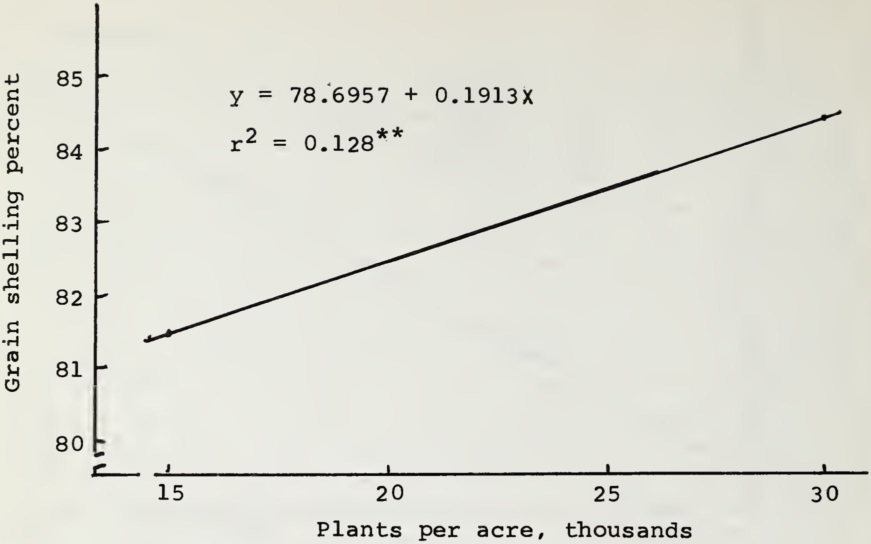

Fig. 3.—Relationship between population density and grain shelling percent in corn hybrids.

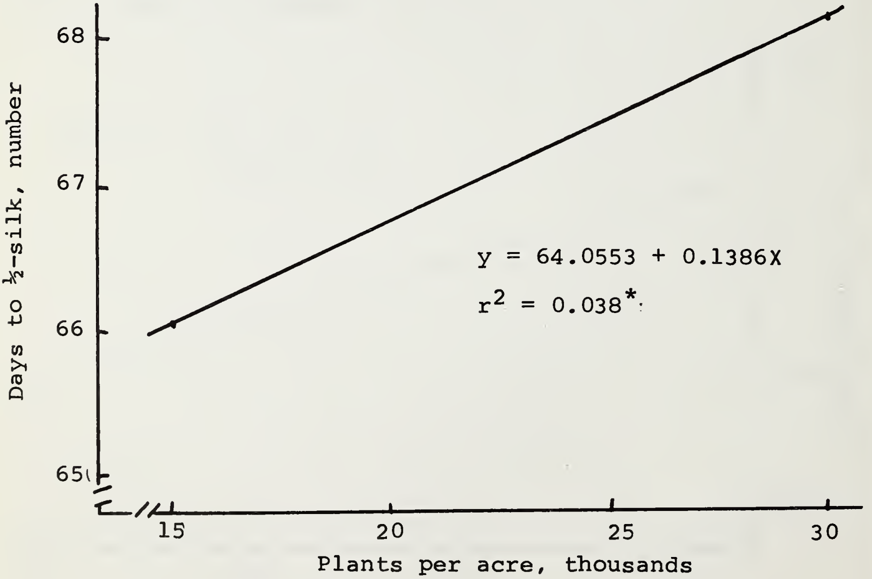

Fig. 4.—Relationship between population density and number of days to silk in corn hybrids.

SUMMARY

1. Hybrids included in the study differed significantly ($P<.05$) in regard to yield, plant and ear heights, ear weight, grain shelling percent, and number of days from planting to flowering.
2. Row spacing had little effect on yield.
3. Population density affected yield, number of ears per 100 plants, ear weight, grain shelling percent, and number of days to mid-pollen.
4. Coker S 48 grain yield was significantly greatest in 26.6-inch rows with 23,900 plants per acre. Funk's G-4761 produced maximum yields at all three row spacings in combinations with populations varying from 19,500 to 27,600 plants per acre. The best yield of Funk's G-4949 occurred in 20-inch rows with 22,600 plants per acre. Pioneer brand 3147 yields did not differ ($P<.05$) between the 26.6- and 20.0-inch row spacings in combination with populations of 19,600 to 28,800 plants per acre.
5. Results of the study showed that Funk's G-4949 responded to the 20-inch row and Coker S 48 yielded best in 26.6-inch rows, while Funk's G-4761 and Pioneer brand 3147 were less sensitive to row spacings.
6. Approximately 11.5 percent of the variance in yield could be attributed to changes in plant population.

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The Impact of Aging on Participation in Social and Leisure Activities in Two Louisiana Parishes

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Preface

The purpose of this monograph is to report the findings of a study that explored the nature and type of social and leisure activities of elderly people in two Louisiana parishes. In general, the data revealed that elderly persons were involved in a variety of social and leisure activities; however, most had experienced severe declines in their level of participation since reaching age 65 or after retirement.

The present report is the culmination of slightly more than ten years of study of the aged by members of the Department of Rural Sociology Research, Louisiana State University. Many persons contributed to the research, and their efforts resulted in more than fifteen publications of various types. Many aspects of social organization related to the life style of the aged and to the problematic nature of their security and well-being were determined and discussed.

The need for improving the position of the aged within the larger society seems quite obvious in light of past investigations. The awareness of this need is enhanced by the fact that aged persons are becoming more numerous, retiring earlier, and living longer, while their earning power, social roles, and social prestige are eroding.

The Department of Rural Sociology Research has not been alone in recognizing the need for learning more about the senior citizens of our state. Other groups that have generated information on this segment of the population or contributed to their betterment include the Louisiana Commission on Aging, the various Parish Councils on Aging, the Louisiana State University Cooperative Extension Service, the Bureau of Aging Services of the Louisiana Health and Human Resources Administration, and the Congregate Nutrition Program and the Retired Senior Volunteer Program of Community Advancement, Incorporated.

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Introduction

The degree to which elderly people are integrated into or isolated from the larger society can be measured by utilization of several social, psychological, economic, and physiological indexes: what they do (their activity), the nature of their relationships with others (their interaction), how they feel (their attitudes), how they are perceived by others (their personalities), what they possess (their socioeconomic status), the state of their physical and mental well-being (their physical and mental health), and how they prepare for aging (their socialization). Within the dimensions of these variables lies the key to an effective transition and adjustment to the inevitability of aging. Emanating from these factors, also, are the social status and life style of the aged. It is unfortunate that as most individuals approach old age, their positions in society erode considerably. This erosion is characterized by occupational retirement, reduced income, economic dependency, loss of an independent household, subordination to adult offspring or institutional control, increased probabilities of illness and physical incapacity, loss of positions of leadership and influence, restrictions on participation in social affairs, and bereavement.[1] Perhaps more disturbing is the fact that in many instances, society, and not the elderly themselves, creates problems related to the transition and adjustment to old age. Societal problems occur because of lack of the development of functional and meaningful social structures for the aged or from severely restricting their roles and positions within the various institutional arenas in which they must live and perform.

The factors enunciated above suggest that the problems with which many senior citizens are confronted are not generic to old age itself. Rather, they are found in the underdevelopment of at least two aspects of the structure of our highly urbanized, formalized, and technological society: (1) the underdevelopment of family, educational, and other systems for the preparation and socialization of young people to the later years of life, and (2) the underdevelopment of the economic and other social structures through which the knowledge, energy, and expertise of elderly people can be effectively exercised and utilized.

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[1] John C. McKinney and Frank T. deVyver, Eds., *Aging and Social Policy*. New York: Appleton-Century-Crofts, 1966, p. 2.

Purpose of the Study

Stated in general terms, the purpose of this study was to analyze the activities of a sample of aged persons. The specific objectives were: (1) to determine the relative involvement of the aged in different types of social activities, (2) to determine the nature and extent of change in participation in various types of social and leisure activities as individuals become aged, and (3) to compare rural and urban older persons with regard to involvement and change in social participation.

Methodology

The study included a sample of 547 persons 65 years of age and over and/or retired from work, drawn from lists provided by the Louisiana Council on Aging.[2] The sampling procedure involved the drawing of names from a list of aged persons in a systematic fashion until the desired quota was met. The first selection from the list for each parish was randomly drawn with the aid of a table of random numbers. In order to determine the nth intervals, the total number of persons for each list was divided, respectively, by the desired sample size. Replacements were selected in the same manner. The percentage of names drawn from each ward (minor civil division) matched the percentage of aged in that ward. The names drawn were then divided into racial and sexual categories so that the racial and sexual percentages of the drawn samples matched the racial and sexual percentages in the total aged population for each parish.

The personal interview technique utilizing an interview questionnaire was employed. The interview schedule was pre-tested on a group of older persons living in Baton Rouge and modifications were made in the schedule where necessary. The interviewing was conducted by a carefully trained team comprised of blacks and whites. A total of 547 interviews were completed, 274 of which were taken from Lincoln Parish and 273 from St. Landry Parish. The racial and sexual composition of the completed sample was 226 blacks and 321 whites, including 234 males and 313 females. Also included were 330 rural residents and 217 urban residents.

Description of Study Area

In order to reflect the cultural diversity in Louisiana, approximately half of the sample was drawn from Lincoln Parish in north Louisiana and the other half from St. Landry Parish in the southern part of the state. St. Landry Parish reflects the predominantly Catholic and French influence of south Louisiana, while Lincoln Parish reflects the predominantly Protestant, Anglo-Saxon/Scotch-Irish influence of northern Louisiana. Both parishes included an urban center of approximately equal size and neither was located adjacent to a large metropolitan area. Neither parish had previously been the subject of an extensive survey of the aged, except for the general survey conducted by the local Council on Aging. The data were collected in the summer of 1974.

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[2] The Louisiana Council on Aging compiled a list of all persons 65 years of age and over for each parish by house-to-house surveys, utilizing the personal interview technique. The lists, compiled approximately one year prior to the present study, included such information as name, address, race, sex, and age for each person.

In 1970, Lincoln Parish had a population of 33,800, 9.3 percent of whom were aged. Of the total 3,149 aged persons (65 years and over) in the parish, 8.7 percent were included in the sample. The major town in Lincoln Parish is Ruston, the parish seat, with a population of 17,365 in 1970. St. Landry Parish had a population of 80,364 in 1970, 8.3 percent of whom were aged. Of the total 6,654 aged inhabitants in the parish, 4.1 percent were included in the sample. The major urban place in St. Landry Parish is Opelousas, which had a population of 20,121 in 1970. Opelousas also serves as the parish seat.

As shown in Figure 1, the percentage of aged in the United States was slightly higher than that for Louisiana in each period between 1930 and 1970. Both the United States and Louisiana showed similar rates of increase in percentage of aged between 1930 and 1970.

It can be seen in Figure 2 that the percent increase in the aged population of Louisiana was greater than that for the aged population of the United States as a whole for each decade period with the exception of the 1960 to 1970 period, where the percent change was slightly higher in the United States (Figure 2A). It can also be observed that the percent change in the total population of the United States and of Louisiana, respectively, increased between 1930 and 1960, but in both instances the percent increase between 1960 and 1970 dropped (Figure 2B). It is of interest that the percent change in aged population in St. Landry Parish was more typical of that for the United States as a whole, except between 1930 and 1940, while the trend in Lincoln Parish was more typical of that occurring in the state (Figure 2A). All these populations moved toward greater similarity in percent increase of the aged population as they approached the 1960 to 1970 period; however, both St. Landry and Lincoln parishes experienced a slightly greater percent increase in the aged population than did Louisiana or the United States between 1960 and 1970.

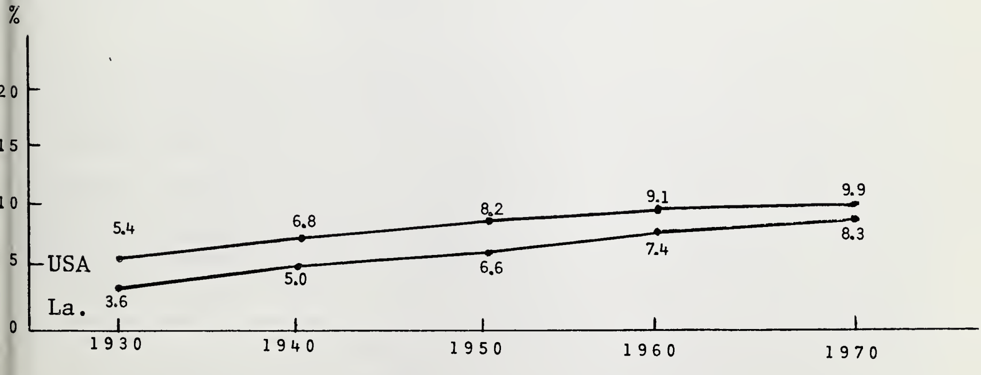

Figure 1.–Percent of total population 65 years of age and over for Louisiana and the United States, 1930-1970.

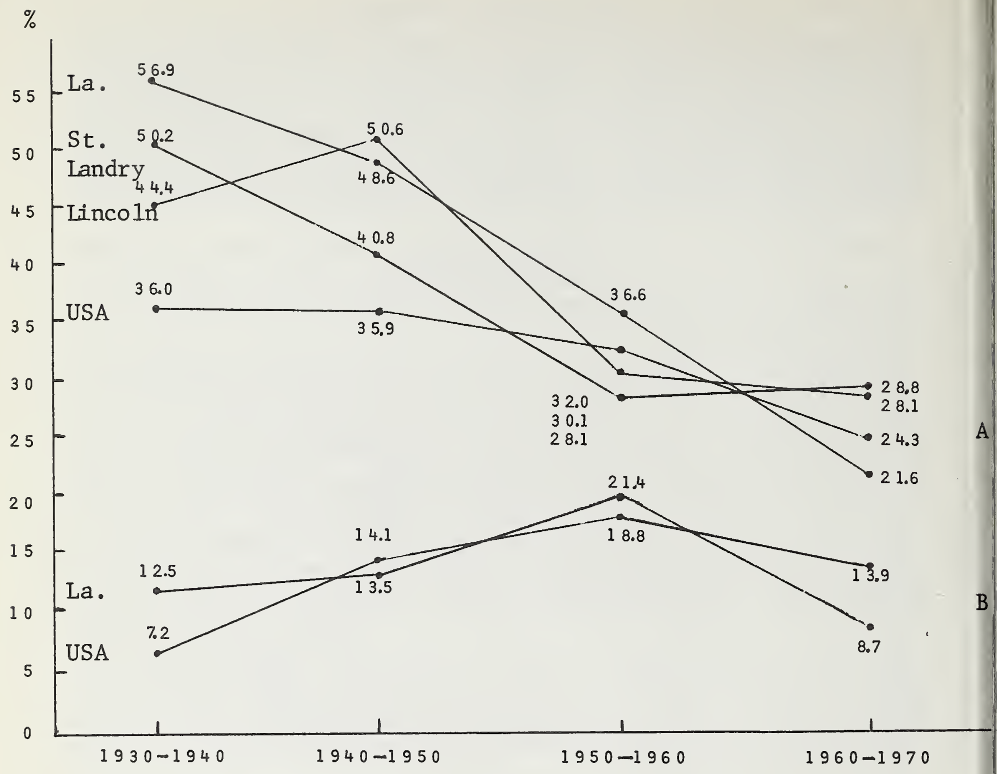

Figure 2.–A. Percent increase of persons 65 years of age and over, United States Louisiana, Lincoln Parish, and St. Landry Parish;
B. Percent increase in total population, United States and Louisiana.

Theoretical Framework

The social world of the aged can become very limited due to a reduction in roles between adulthood and old age. This tends to make life for the aged problematic in terms of their well-being. Many aged persons apparently exist in a social world of their own largely removed from other age groups. They are not necessarily happy or unhappy or satisfied or dissatisfied with life. Their life satisfaction, however, depends on a complex of social, economic, psychological and physiological factors the interrelationships of which are not yet fully understood. It is clear, however, that whether or not one becomes adjusted to aging is a function of social structure—that is, the nature and degree of interrelationships within the institutional networks of society, including education, occupation, religion, government, leisure, family, and the community in general.

The so-called ''problems'' of the aged for many people are not generic in age or physiological status, but are inherent in the social or institutional structure of American society. These problems stem basically from the lack of development of

Table 1.–Theoretical model designed to show the structural dimensions, corresponding correlates and their consequences for the aged*

Dimensions	Corresponding Correlates	Consequence
A. Chronological	Chronicity 1. Age 2. Number of years retired 3. Community longevity	
B. Physiological	Status Resource 1. Discontinuity in health status 2. Number and type of ailments	
C. Social Psychological	Socialization & Attitudes 1. Anticipatory socialization 2. Concomitant socialization 3. Life satisfaction 4. Retirement satisfaction	
D. Sociological	Status-Resources 1. Discontinuity in occupational status 2. Discontinuity in income level 3. Level of education	Sociological Consequences 1. Social-Leisure participation 2. Structural integration
	Structural 1. Discontinuity in marital and household positions	
	Processual 1. Discontinuity in informal activities 2. Discontinuity in formal participation	
E. Controls or Situational Factors	Situational 1. Color 2. Sex 3. Residence 4. Religion	

*Causality, though theoretically possible, is, however, not implied in the above schema. This schema is a modification of the theoretical model constructed by William Eteng, unpublished Ph.D. dissertation, Department of Rural Sociology, The University of Wisconsin, Madison, 1972.

a system of preparation or "socialization" of young people for old age and for interrelating with the aged. In other words, in our society, there is inadequate development of meaningful roles and role-relationships through which the knowledge, energy, and expertise of the aged can be effectively exercised and utilized and through which they can maintain dignity and a sense of usefulness. The aged poor are in a special state of deprivation when it is considered that they are further limited and restricted by their relative economic disadvantage.

The sources of the problem outlined above are varied and complex. Table 1 was prepared to show the problem in the form of a theoretical model. Although the variables included in this model are limited to a selective number, they provide a conceptual perspective for contemplating the status and role transition which accompany getting old. The report which follows was prepared with this theoretical framework in mind, although not all of the variables included were utilized in the analysis.

The Socioeconomic Characteristics of Respondents

This section of the report is devoted to an outline of selected characteristics of the persons interviewed. The discussion is designed to provide a background for the information and analysis which follow.

Education

Low educational level is a serious problem among the aged in the state and nation. About one-fourth of the 546 persons who responded had received no formal education. Forty-four percent had completed some level of elementary school, but the substantial majority (79 percent) did not have a high school diploma. Only about 9 percent had spent the time necessary for a college degree in terms of years in school (Table 2).

Table 2.–Educational attainment of respondents

Years of School Completed	Number	Percent*
None	132	24.2
1-8	239	43.8
9-11	61	11.2
12	36	6.6
13-15	30	5.5
16 and over	48	8.9
Total	546	100.2

*In this table and in successive tables, percents may not total to 100.0 due to rounding error.

Occupation

One characteristic that is typical of the aged is reduction or loss of the work role. Although 91 percent of the respondents reported that they were not physically disabled, almost three-fourths said they were presently unemployed. By contrast, only 4 percent were employed full-time and about the same percentage held part-time jobs. Eighteen percent had never worked. These persons were mostly housewives.

Respondents were asked what type of job they had before becoming aged and/or retiring. Approximately 19 percent of the respondents reported holding white collar jobs before retirement, as compared with 81 percent who said they held blue collar jobs.[3] For the 146 persons reporting retirement occupations, only 14 percent held white collar jobs while 86 percent worked in blue collar jobs (Table 3).

Between pre-retirement and retirement, it was found that persons employed in professional, technical, and kindred workers positions declined by 94 percent as compared with a drop of 67 percent for managers and administrators and 54 percent for sales workers. The decrease in the number of persons in all occupations was high, but was somewhat higher for farm laborers, laborers, farmers and farm managers, private household workers, and professionals (Table 3).

Table 3.–Occupational characteristics of respondents, pre-retirement and retirement

Occupational Category	Pre-retirement Occupation Number	Pre-retirement Occupation Percent	Retirement Occupation Number	Retirement Occupation Percent
Professional and technical	50	9.2	3	2.1
Managers and administrators	21	3.9	6	4.1
Sales	13	2.4	6	4.1
Clerical	19	3.5	4	2.7
Craftsmen and foremen	21	3.9	6	4.1
Operatives	37	6.8	5	3.4
Laborers (except farm)	52	9.6	2	1.4
Farmers and farm managers	41	7.6	2	1.4
Farm laborers	81	15.0	2	1.4
Service	57	10.5	10	6.8
Private household	48	8.9	3	2.1
Homemaker	98	18.1	97	66.4
Military	3	0.6	-	-
Total	541	100.0	146	100.0

Income

The data revealed that most of the persons in the sample group were in the lower income levels (Table 4). After retirement, a clear two-thirds of the respondents had annual family incomes of less than $3,000. One-fourth of them were not much better off, having reported an annual family income between $3,000 and $6,999.

The data revealed that 51 percent of the persons interviewed reported pre-retirement family incomes below $3,000 (Table 4). There was a substantial increase of persons with family incomes below $3,000 at the time of retirement—66 percent. Nearly one in 10 (9.0 percent) reported pre-retirement incomes of over $10,000, but only about half as many retirees (5.4 percent) reported incomes at the same level.

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[3] White collar workers: Professional and technical; managers and administrators, except farm; sales; clerical.

Blue collar workers: Craftsmen and foremen; operatives; nonfarm laborers; farm laborers; service workers; private household, homemakers.

Table 4.—Family income for respondents, pre-retirement and retirement

Income Category (dollars)	Pre-retirement Income		Retirement Income	
	Number	Percent	Number	Percent
None	40	9.2	0	0.0
0-999	76	17.5	22	4.2
1000-1999	58	13.4	187	35.7
2000-2999	49	11.3	139	26.5
3000-3999	45	10.4	65	12.4
4000-4999	29	6.7	38	7.2
5000-5999	25	5.8	12	2.3
6000-6999	26	6.0	14	2.7
7000-7999	21	4.8	7	1.3
8000-8999	15	3.4	10	1.9
9000-9999	11	2.5	2	0.4
10,000-18,999	24	5.6	21	4.1
19,000 & over	15	3.4	7	1.3
Total	434	100.0	524	100.0

The two major sources of income were Social Security (75 percent) and old age pension or government assistance (42 percent), and only a few (7 percent) received their income from self-employment. Other sources of income are reported in Table 5.

Table 5.—Sources of income of respondents

Source	N = 539	
	Number	Percent
Social Security	410	76.1
Old Age Pensions	224	41.6
Retirement	104	19.3
Interests	74	13.7
Employment	38	7.0
Stocks & Bonds	30	5.6
Farming	24	4.4
Other	96	17.8

Health

Health problems tend to increase with advancing age. The study revealed that two-thirds of the respondents reported that they made more visits to the doctor since becoming older. Elderly people also experience a wide variety of ailments. The most common reason reported for visiting the doctor was circulatory system disorders, including high blood pressure, heart trouble, strokes, and hardening of the arteries. Other reasons mentioned less frequently by the respondents were arthritis conditions, musculoskeletal disorders, digestive disorders, diabetes, genitourinary problems, and eye, ear, nose, and throat disorders. Arthritis is a health problem for most persons aged 65 or over in St. Landry and Lincoln parishes (according to survey) but they don't go to the doctor every time they suffer pain. Other reasons for visiting the doctor are reported in Table 6.

Table 6.–Respondents' reasons for doctor visits

Ailment	First Reason Stated		Second Reason Stated	
	Number	Percent	Number	Percent
Circulatory	144	41.4	43	23.9
Arthritis	35	10.1	25	13.9
Check-ups	31	8.9	7	3.9
Musculoskeletal	28	8.0	7	3.9
Digestive	25	7.2	15	8.3
Diabetes	17	4.9	14	7.8
Genitourinary	16	4.6	14	7.8
Eye, ear, nose, throat	16	4.6	19	10.6
Respiratory	7	2.0	16	8.9
Operations	7	2.0	7	3.9
Cancer	7	2.0	2	1.1
Accidents	6	1.7	-	-
Mental	5	1.4	4	2.2
Nerves	4	1.1	7	3.9
Total	348	99.9	180	100.1

The health problems reported by the elderly appear to reflect their adverse social, economic, and physiological conditions. In fact, health was ranked as the most serious problem by 28 percent of the respondents. This was followed by lack of money or financial problems (26 percent), mental and emotional problems (15 percent), inactivity (12 percent), transportation (9 percent), and relating to others (4 percent) (Table 7).

Table 7.–Respondents' rankings of the most serious problems of the aged

Problem Area	Rank 1st		Rank 2nd		Rank 3rd	
	Number	Percent	Number	Percent	Number	Percent
Health	140	28.4	73	23.8	30	21.1
Money	126	25.6	77	25.1	25	17.6
Transportation	44	8.9	27	8.8	18	12.4
Mental	74	15.0	38	12.4	26	18.3
Inactivity	58	11.8	41	13.4	23	16.2
Relating to other persons	22	4.5	25	8.1	8	5.6
Others	28	5.7	26	8.5	12	8.5
Total	492	99.9	307	100.1	142	100.0

Housing

The majority of the elderly interviewed lived in single family dwelling units with an average of five rooms per house. About one-fifth of the respondents lived in houses in poor repair status.

Household Composition

Slightly more than one-fourth of the respondents lived alone, while two-thirds were living in two-person households. Households of three or more persons were reported by about 18 percent of the respondents, indicating they lived with relatives or friends. As revealed by the data obtained, a little over 80 percent of the respondents had no children living in their households, despite the fact that the average number of living children per respondent was 3.4. The vast majority (93 percent) also had no grandchildren living with them. Less than 2 percent lived with a parent, while 5 percent lived in a house with other relatives.

Residential Mobility

Most of the elderly persons interviewed (72 percent) had not been residentially mobile. Slightly over fifty percent had resided in the same house for 20 years or more. As many as 79 percent had lived in the same community for 20 years or more (Table 8). This indicates that most of the respondents had remained in the same village or community all their lives.

Table 8.—Years respondents reported living in their present house and community

	Years Lived in Same House		Years Lived in Same Community	
Years	Number	Percent	Number	Percent
0-9	154	28.2	57	10.5
10-19	103	18.8	57	10.5
20-29	114	20.8	68	12.5
30-39	79	14.4	61	11.3
40-49	54	9.9	64	11.8
50-59	32	5.9	59	10.9
60-69	11	2.0	71	13.1
70-79	-	-	82	15.1
80-89	-	-	16	3.0
90 & over	-	-	7	1.3
Total	547	100.0	542	100.0

Patterns of Social Activity Participation Among Aged Respondents

The purpose of this section is to report findings pertaining to the effects of becoming aged on participation in social, recreational, and leisure activities[4] of a group of elderly respondents. The main concern was to determine whether or not changes in social activities were related to residence, sex, income, education, and race for a sample of older persons.

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[4] Hereafter referred to mostly as social activities.

Activities Reported by Respondents

During the later years of life when many roles and activities decline in intensity or cease altogether, social participation and leisure activities can play an important part in promoting a congenial, integrated, and healthy social adjustment for the elderly. In a broad sense, social activities are the essence of life for persons of any age and help to make life more fulfilling and meaningful.

Different social activities involve varying degrees, types and levels of interaction or social contact with others. This leads to an important question. That is, to what extent are certain social activities congruent with being aged or enjoyed by elderly people? An attempt to provide an answer to this question is made in this section.

The data revealed that the social world of the aged studied was comprised of a variety of social, recreational, and leisure activities. Family or home centered activities engaged in by the respondents included watching television or listening to the radio, house or garden work, telephone conversations, reading, parties or celebrations, and card games. Community centered activities reported were visiting friends and relatives, shopping, taking walks, church work, outdoor recreation, and moviegoing (Table 9).

In order to determine the relative frequency with which an activity was engaged in before and after retirement an activity tendency score (ATS) was computed. This score included a weight for responses such as "never engaged in," "do more than before retirement," and "do less than before retirement." The computation of activity tendency scores made possible a ranking of the activities mentioned on the basis of increase or decrease in participation after becoming aged (Table 9). The results indicate that while elderly persons continued to be involved in a variety of social activities, their level of participation changed in these activities from pre-retirement to retirement age. The scores computed show a clear tendency for the elderly to become more involved in relatively low interaction, low physical effort demanding, informal activities, and, conversely, a tendency to become less involved in relatively high interaction, high physical effort demanding, formal types of activities. Accordingly, watching TV or listening to the radio was by far the most popular activity reported by the respondents, with indication of increased involvement upon becoming old. The more "youthful" activities such as parties, movies, and traveling definitely lost popularity with the aged interviewed.

The above patterns are corroborated by the data presented in Table 10, which show what has been termed the discontinuity score for each activity. The discontinuity score for a given activity represents the ratio of the number of declines in the activity to the sum of the declines and increases (see Table 10). Thus, the greater the magnitude of the score, the higher the discontinuity of a given activity upon becoming aged. It may be observed that the activities with the lowest degree of discontinuity and the highest tendency rank were considered the ones most popular among the aged. For example, watching TV or radio listening, telephone conversations, and reading showed the lowest amount of discontinuity for the sample group and were the only activities where increases in activity exceeded decreases. High discontinuity activities were movies, parties, outdoor recreation, and card games. Activities ranking intermediate on the discontinuity scale were visiting friends, gardening, taking walks, visiting relatives, church work, and shopping, in that order.

Table 9.–Types and changes since retirement in social activities engaged in by respondents

	.0	.1	.2	.3			
Activity	Never	Less Since Retirement	Same Since Retirement	More Since Retirement	ATS* Score	Rank	N
	(N)	(N)	(N)	(N)			
Watch TV or listen to radio	14	92	146	292	126.3	1	545
House or yard work	34	216	130	166	97.4	2	547
Visiting friends	15	248	135	148	96.2	3	547
Visiting relatives	18	254	143	128	92.4	4	544
Telephone conversations	90	121	194	137	92.0	5	543
Shopping	30	229	184	100	89.9	6	544
Taking walks	58	258	86	140	85.0	7	543
Gardening	82	253	73	137	81.0	8	545
Traveling outside the community	63	294	90	95	75.9	9	542
Church work	119	201	122	100	74.5	10	543
Reading	180	135	82	145	73.4	11	543
Hobbies	243	133	48	114	57.1	12	539
Outdoor recreation	189	233	48	74	55.1	13	544
Parties or celebrations	224	200	80	38	47.4	14	543
Card games	310	147	36	52	37.5	15	546
Movies	345	164	25	1	21.7	16	536

*Each Activity Tendency Score (ATS) represents the sum of the response number in each category multiplied by the weight for that particular category. For example, the activity score for "visiting friends" was computed as (15 X .00) + (248 X .1) + (135 X .2) + (148 X .3) = 96.2 score range: 0-164.2.

The above findings have implications for those interested in developing programs for the aged. Activity programs can be planned to supplement or complement the things they tend to "inherit" as they become aged.

Table 10.–Discontinuity* in social activities since becoming aged reported by respondents

Social Activity	Score	Rank
Watch TV or listen to Radio**	.2389	16
Telephone Conversations**	.4690	15
Reading**	.4840	14
Hobbies	.5385	13
House and yard work	.5666	12
Visiting friends	.6263	11
Gardening	.6487	10
Taking walks	.6491	9
Visiting relatives	.6658	8
Church work	.6678	7
Shopping	.6960	6
Card games	.7400	5
Traveling outside community	.7558	4
Outdoor recreation	.7590	3
Parties and celebrations	.8410	2
Movies	.9939	1

*The discontinuity score represents a ratio of the number of declines in social activities to the total number of declines and increases. For example, the score for the activity "movies" which yielded responses of 164 (less than) and 165 (sum of less than and more than) is computed as 164/165 = .9939.

**These were the only activities where increases exceeded decreases. Note that (CS) continuity score = 1.000 minus (DS) discontinuity score.

Residence Differences in Social Activities

The social activity of watching TV or listening to the radio ranked first in popularity among the elderly living in both rural and urban areas. The least popular activities in both areas were movies, card games, parties or celebrations, outdoor recreation, and hobbies (Table 11).

There were some differences in social activities between rural and urban dwellers, however. House or yard work ranked second in popularity among the urban residents and third in popularity among rural residents. Shopping ranked fifth in popularity in rural areas and sixth in urban areas. Greater differences occurred for visiting friends and telephone conversations, the former ranking second among ruralites and fifth among urbanites, while the latter ranked sixth for rural residents and third for urban residents.

Table 11.–Differential popularity of selected social activities by rural and urban respondents

	.0		.1		.2		.3						
Activity	Never		Less		Same		More		Score*		Rank		N
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	
Watch TV or listen to radio	10	4	47	45	90	56	180	112	76.7	49.3	1	1	544
House or yard work	23	11	138	78	81	49	87	79	56.1	41.3	3	2	546
Visiting friends	9	6	154	94	72	63	94	54	60.0	38.2	2	5	547
Visiting relatives	10	8	167	87	78	65	72	56	53.9	38.5	4	4	543
Telephone conversations	69	21	62	59	120	74	76	61	53.0	39.0	6	3	542
Shopping	19	11	139	90	105	79	63	37	53.8	35.9	5	6	543
Taking walks	38	20	152	106	50	36	85	55	50.7	34.3	7	7	542
Gardening	48	34	162	91	42	31	76	61	47.4	33.6	8	8	545
Traveling outside community	41	22	188	106	49	41	50	45	43.6	32.3	9	9	542
Church work	86	33	115	86	71	51	55	45	42.2	32.3	10	10	542
Reading	125	55	71	64	44	38	85	60	41.4	32.0	11	11	542
Hobbies	162	81	79	54	25	23	56	58	29.7	27.4	13	12	538
Outdoor recreation	113	76	144	89	25	23	46	28	33.2	21.9	12	13	544
Parties or celebrations	145	79	111	89	47	33	23	15	27.4	20.0	14	14	542
Card games	192	118	83	64	24	12	30	22	22.1	15.4	15	15	545
Movies	227	118	80	84	13	12	1	0	10.9	10.8	16	16	535

*Each score represents the sum of the response number in each category multiplied by the weight for that particular category. For example, the activity score for "visiting friends" was computed as (Rural): (9 X .00) + (154 X .1) + (72 X .2) + (94 X .3) = 60.0.

It was considered of importance to determine the extent to which residence, rural or urban, contributed to change in social activity after becoming aged. The data showed that, although elderly people tended to watch TV and listen to the radio to a high degree as a whole, rural elderly persons participated in this activity more than did the urban elderly after retirement. Telephone conversations and reading also increased more among the rural aged than among the urban aged. Urban older persons, in contrast, showed a slightly greater tendency toward maintaining their involvement in hobbies and house and yard work than did rural older persons.

In 12 of the 16 social activities studied, participation declined for both rural and urban older persons (Table 12). The greatest declines among ruralites occurred for traveling, outdoor recreation, visiting relatives (who probably lived some distance away), parties, and gardening. In the urban areas, movies, parties, traveling, outdoor recreation, and shopping declined more than other types of activities. The greatest differences between the rural and urban elderly, with regard to declines in activities, occurred for traveling, visiting relatives, gardening, outdoor recreation, and shopping, in which the rural elderly participated less than their urban counterparts.

The above findings were considered somewhat indicative of patterns of behavior but not extremely precise in terms of degree. For this reason discontinuity scores for the various social activities were computed for rural and urban respondents as shown in Table 13. When these scores were ranked, more discrepancies in behavior appeared between the ruralites and the urbanites because the discontinuity scores make a finer distinction between the social activities than the activity tendency score (ATS). Specifically, greater differences in behavior occurred for visiting relatives, gardening, and traveling, in which the rural elderly participated less than their urban counterparts. The same rank difference occurred for taking walks, but in this instance the rural elderly participated more than the urban elderly. In addition, urban elderly persons tended to read, visit friends, and go shopping slightly less than their rural counterparts. The urban elderly also appeared to favor hobbies more than the rural elderly. Only minor and insignificant differences occurred between the rural and urban elderly with regard to telephone conversations, house or yard work, church work, card games, and outdoor recreation (Table 13).

Table 12.–The tendency of rural and urban respondents to change social activities after becoming aged

Activity	Never (%)		Less (%)		Same (%)		More (%)		ATI*		Rank		N
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	
Watch TV or listen to radio	1.8	.7	8.6	8.3	16.5	10.3	33.1	20.6	+24.5	+12.3	1	1	544
Telephone conversations	12.7	3.9	11.4	10.9	22.1	13.6	14.0	11.2	+2.6	+.3	2	3	542
Reading	23.1	10.1	13.1	11.8	8.1	7.0	15.7	11.1	+2.6	-.7	3	5	542
Hobbies	30.1	15.0	14.7	10.0	4.6	4.3	10.4	10.8	-4.3	+.8	4	2	538
House and yard work	4.2	2.0	25.3	14.3	14.8	9.0	15.9	14.5	-9.4	+.2	5	4	546
Card games	35.2	21.6	15.2	11.7	4.4	2.0	5.5	4.0	-9.7	-7.7	6	10	545
Visiting friends	1.6	1.1	28.2	17.2	13.2	11.5	17.2	9.9	-11.0	-7.3	7	8	547
Church work	15.9	6.1	21.2	15.9	13.1	9.4	10.1	8.3	-11.1	-7.6	8	9	542
Gardening	8.8	6.2	29.7	16.7	7.7	5.7	13.9	11.2	-15.8	-5.5	12	6	545
Taking walks	7.0	3.7	28.0	19.6	9.2	6.6	15.7	10.1	-12.3	-9.5	9	11	542
Visiting relatives	1.8	1.5	30.8	16.0	14.4	12.0	13.3	10.3	-17.5	-5.7	14	7	543
Shopping	3.5	2.2	25.6	16.6	19.3	14.5	11.6	6.8	-14.0	-9.8	10	12	543
Outdoor recreation	20.8	14.0	26.5	16.4	4.6	4.2	8.4	5.1	-18.1	-11.3	15	13	544
Parties or celebrations	26.8	14.6	20.5	16.4	8.7	6.1	4.2	2.8	-16.3	-13.6	13	15	542
Movies	42.4	22.2	15.0	15.7	2.4	2.2	0.2	0.0	-14.8	-15.7	11	16	535
Traveling outside community	7.6	4.1	34.7	19.6	9.0	7.6	9.2	8.3	-25.5	-11.3	16	13	542

*Activity tendency indicator; computed as the difference between proportion of decrease ("less") and the proportion of increase ("more").

Table 13.–Discontinuity* in social activities after retirement of rural and urban respondents

Social Activity	Score		Rank	
	Rural	Urban	Rural	Urban
Watch TV or listen to radio	.2070**	.2866**	16	16
Telephone Conversation	.4493**	.4917**	15	14
Reading	.4551**	.5161	14	12
Hobbies	.5852	.4821**	13	15
House and yard work	.6133	.4968**	12	13
Visiting friends	.6210	.6351	11	9
Gardening	.6807	.5987	8	11
Taking walks	.6414	.6584	10	7
Visiting relatives	.6987	.6084	6	10
Church work	.6765	.6565	9	8
Shopping	.6881	.7087	7	5
Card games	.7345	.7442	5	4
Traveling outside community	.7899	.7020	3	6
Outdoor recreation	.7579	.7697	4	3
Parties and celebrations	.8284	.8558	2	2
Movie	.9876	1.0000	1	1

* The discontinuity score represents a ratio of the number of declines in social activities to the total number of declines and increases. For example, the score for the activity "movie" which yielded responses of 80 (less than) and 81 (sum of less than and more than) is computed as 80/81 = .9876.

**These were the only activities where increases exceeded decreases. Note that (CS) continuity score = 1.0000 minus (DS) discontinuity score.

Changes in Social Activities of Open Country, Small Town and Urban Residents After Becoming Aged

Sex Differences in Changes in Patterns of Activities, by Residence

Watching TV or listening to the radio was found to be popular among both males and females in all three residence areas (Table 14).[5] However, some interesting differences appeared. First, more open country females than males said they listened to the radio and watched TV less after reaching retirement age. Second, relatively more urban females than urban males increased their participation in this type of activity. Third, a larger percentage of open country and urban males than of females did not change their TV and radio habits. Fourth, a larger percentage of small town females than males did not change their activity patterns.

All in all, it appears that some sex difference in change of activity patterns occurs by residence, but for the most part men and women tend to change their TV and radio patterns in roughly the same way.

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[5] Please note that Tables 14-37 are in the Appendix.

Open country and small town females were likely to do less reading than males in these residence groups (Table 15). Open country males and urban females showed a greater tendency to increase their reading than did open country females and urban males. Surprisingly, open country and small town males were more inclined to increase their reading time than were urban males. The proportion reporting an increase in reading, however, was higher for males than for females in all residence areas except urban. However, a higher proportion of males than females in all classes reported they never read.

The telephone is considered a boon to the aged in the United States because of the ease with which one can communicate with relatives and friends and because of its accessibility. This was the third activity tested for changes in patterns by residence and sex. The findings supported the stereotype that females converse more on the telephone than males, especially in urban settings. Females increased their telephone conversations to a much greater extent than did males after becoming aged in small town and urban areas (Table 16). The fact that differences in changes in patterns occurred among open country residents and that a higher percentage of respondents there ''never'' used the telephone no doubt reflects both the fewer number of telephones and less dependence on this means of communication.

There was a considerable decrease in visiting friends among both sexes after becoming aged, but more females than males in all residence areas experienced a rather sharp decrease in this activity. Males, as might be expected, tended to increase their visiting. Also, as expected, visiting friends declined more in popularity for open country and small town females than for males of the same areas. Also, females of both urban and small town areas reported visiting friends more than did those of the open country (Table 17).

As shown in Table 18, church work of respondents as a social activity increased somewhat for both males and females after becoming aged in all residence areas. There was little difference between the sexes in this respect. Since females are usually the more active church workers, it is logical to expect them to retire from this activity in larger numbers than males. This is exactly what occurred, as indicated in Table 18. The proportion of respondents whose church work declined was greater for females than for males in all residence areas. Males exhibited declines in all residence areas; however, they participated less in church work than did females in small towns and urban areas.

Visiting relatives became less popular among females than among males after retirement. At least, larger percentages in all residence categories said they did such visiting less. By contrast, relatively more open country and small town males reported an increase in their visiting patterns than did females from these places. The opposite was true for uban dwellers (Table 19).

Income Class Related to Differences in Changes in Patterns of Activities, by Residence

The researchers expected that income levels would be related to changes in patterns of activities and that such changes would vary by place of residence. For this reason, the family income of respondents was determined and divided into two classes—low income and high income. This information was cross tabulated with responses relative to changes in activities and residence.

The data revealed that the low income elderly (family incomes of less than $6,000) in small towns definitely increased their watching of TV and listened to the radio more than did elderly residents of the open country and urban areas (Table 20). Three of every five of the 172 respondents living in small towns reported that they engaged in this activity more since becoming old. It is interesting that viewing and listening increased less among low income open country residents than among any other residence group. However, the fact that one out of five urban dwellers indulged less in this activity is also significant, especially since this rate was higher for low income open country and small town residents.

Of the interviewees falling into the higher family income category ($6,000 or over), urban and small town residents increased their TV viewing and radio listening considerably more than did open country dwellers. It is difficult to explain why such a large percentage of open country residents (30 percent) decreased their use of TV and radio. It is probable that the small number of individuals in the study population was not typical of the total populace.

It was found that higher income older persons read more after becoming aged than did lower income older persons. Second, urban residents with low income tended to have their reading habit affected more by becoming old than did open country or small town residents. In all three residence groups, however, about one-fifth of the respondents read more after becoming aged. It is also true that one-fifth of the low income older people interviewed indulged in this activity less after becoming old. Third, higher income persons increased their reading more than low income persons in all three residence groups, although urban dwellers were much more prone to do so.

It is of interest that those who reported that they never used a telephone ranged from 6.4 percent among urban high income persons to 30.9 percent among open country low income respondents (Table 22). This is revealing since it was reasoned that use of the telephone among the aged would help compensate for their reduced physical mobility. Another finding was that approximately 32 percent of the higher income urban residents used this means of communication less since retirement. This was a greater relative decrease than experienced by any other income group. The probable explanation is that urbanites did not have as much business and social life as before. By contrast, a relatively larger number of open country and small town respondents in the higher income category used the telephone more after becoming old than did their urban counterparts. It is possible that many older persons had telephones installed for the first time after reaching age 65. The detailed changes in this activity are shown in Table 22.

The more interesting discoveries relative to income levels and changes in visiting friends were as follows: (1) Higher income individuals, especially those living in the open country and in small towns, increased their visiting with friends relatively more after reaching retirement age than did lower income persons; and (2) almost half of the lower income respondents residing in small town and urban places reported that they visited friends less since they became old, while over half of those in the open country gave the same response (Table 23). These patterns suggest that the availability of transportation may be important in non-urban places. This conjecture is supported by the finding that only a third of the higher income persons said they reduced their number of visits with friends.

Church work was engaged in less by older persons, whether they were in high or low income brackets and regardless of place of residence (Table 24). Of course, it should be noted that slightly over one-fourth of the open country and small town groups, respectively, had never done church work. The more affluent, especially the urban and open country dwellers, seemed to have increased their church work more upon becoming older than did all classes of low income persons. Another finding of the study that is rather surprising is that urban persons seemed to have increased their church work more than persons living in non-urban places. A conclusion that comes from the data is that urban and small town churches as well as those of the open country might do well to develop more programs and activities designed to involve the aged.

From the data utilized, it was apparent that visiting relatives declined as age increased, except among persons of small towns with relatively high incomes. It was found that sizeable percentages of respondents with relatively low incomes, regardless of place of residence, reported visiting relatives less than they did before becoming old or retired. In fact, as many as three out of five persons living in the open country reported that they visited relatives less, while just over half of the respondents of small towns were characterized by such behavior. In addition, close to half (45 percent) of the urban lower income group said they visited relatives less. Open country and small town residents in the upper income bracket appeared to increase their visiting of relatives markedly, while urban dwellers with the same level of affluence changed their visiting patterns moderately.

Formal Educational Attainment Related to Differences in Changes in Patterns of Activities, by Residence

Educational attainment tends to correlate with various socio-personal characteristics. It is therefore logical to assume that changes in patterns of activities after becoming aged would be associated with educational attainment. For this reason, the patterns of activity changes of respondents were related to their place of residence and educational attainment.

It was found that regardless of educational or residential class, respondents reported an increase in TV watching and radio listening (Table 26). Of interest in this respect is the fact that almost two out of five urban residents with education beyond the high school diploma said they never watched TV or listened to the radio. This seems to be an expression of bias among the so-called sophisticated urban dwellers. However, about the same percentage of this group reported participating in this activity more since becoming aged or retired.

Reading was not found to be a popular activity among the aged with little education who resided in the open country and small towns. Furthermore, older respondents with higher formal educational attainment in small towns and urban places tended to increase their reading after becoming aged or retired more than did persons with lower educational attainment. It is noteworthy, however, that a considerable number of persons of all educational levels and residence areas decreased their reading after reaching retirement years.

The findings revealed no wide differences in changes in the use of the telephone for holding conversations by rural and urban persons of different levels of educational attainment. Where differences did appear, the extremely small number of respondents in the categories made interpretation of the results hazardous. In such cases, the number was too small to support generalizations.

Persons with less than a high school education apparently do not visit friends as much after becoming old as do persons with more formal educational training. This pattern holds true despite place of residence. By contrast, persons with at least a high school education and who lived in small towns or cities reported that they engaged in this type of activity to a greater extent after reaching retirement age. When persons who did not change their habits of visiting friends were sorted according to place of residence, urban dwellers, regardless of income, were found to be least affected by becoming aged. Education appears, however, to have at least some correlation with changes in visitation patterns (Table 29).

Church work appeared to decrease with age, especially among those with less than a high school education. This was true whether residence was maintained in the open country, small town, or urban areas. Residence, however, appeared to have significance with respect to high education. Close to one-third of the respondents with more than a high school education living in small towns and urban places increased their level of church activity after reaching retirement age. The interesting discovery that is apparent from Table 30 is that open country residents with higher education did not participate in church work as much after becoming old as did the more highly educated living in small towns or cities.

Respondents with the lowest levels of education were found to do less visiting of relatives than those with higher levels of education (Table 31). Regardless of whether they lived in the open country, small towns, or cities, about half of the respondents in the lower educational bracket reported that they visited relatives less after becoming old. Most of those in the higher educational group said that they increased such visits. In fact, the picture seems fairly clear that educational level is an overriding factor in changes in this type of activity. The only exception is that relatively large numbers of open country dwellers with higher education claimed that they visited with relatives less. The reason the more highly educated persons tended to increase their visiting with relatives after reaching retirement age is not clear. A logical explanation appears to be that they are more affluent and can afford the costs of travel necessary to visit sons and daughters and other relatives. They also may be more willing to travel.

Race as Related to Differences in Changes in Patterns of Activities, by Residence

The final variable tested for differences in changes in patterns of activities for elderly respondents of the study was race. Almost all studies that compare whites and blacks indicate that cultural differences may override factors such as age, income, and education. This was why an analysis by race and residence was conducted.

Television viewing and radio listening did not vary greatly by race for the different residence categories. An interesting finding, however, is that blacks and whites of small towns tended more toward viewing and listening than did their open country and urban counterparts. As one goes from open country to small town to urban, this activity declined among blacks slightly more than for whites, especially in small towns and urban areas (Table 32).

The analysis revealed that a greater proportion of urban whites than urban blacks reported doing more reading after becoming old. This pattern also existed in the open country, although the difference was not as great (Table 33). Among small town residents, blacks reported a slightly greater tendency against changing reading habits than did whites. There was little difference in the relative number of black and white older persons who reported reading less, by residence. A far greater proportion of blacks than whites reported little or no reading in all residence areas, although the differences were greater in the open country and urban areas than in small towns. These differences are probably explained by the usually lower levels of education and income of blacks and are a reflection of past educational systems for blacks.

In all residence areas, the proportion of blacks who reported having never used the telephone was higher than that for whites. This explains why urban whites tended to increase their use of the telephone as they aged, to a greater extent than urban blacks. The opposite was true in small towns where blacks increased their use of the telephone more than whites. Race differences regarding decrease in use of the telephone were not great in any of the residence areas; however, declines in use were slightly greater for whites living in the open country than for blacks of this area (Table 34).

Findings of the study show that church work became more popular for blacks than for whites upon becoming old, the greatest difference in this respect occurring in small towns. In terms of the relative number of persons saying they did less church work, patterns were similar for blacks and whites in all three residence areas, with urban blacks showing a slightly greater propensity toward a decline in this activity. Quite striking is the high proportion of whites of small towns (38 percent) reporting little or no church work as compared with only 10 percent of the blacks. Urban whites also showed a tendency toward lesser involvement in church work than did urban blacks (Table 35).

In all three residence classes the visitation of friends declined more among elderly blacks than among elderly whites, although the difference was greater in the open country setting. In contrast, no significant race differences appeared in the open country or small towns regarding visiting friends (Table 36). However, the increase in this activity was slightly greater for blacks than for whites of the same areas. The greatest difference occurred in the urban area, where a greater proportion of elderly whites increased their visiting of friends than was the case for elderly blacks.

The data revealed that visiting relatives increased more among small town and urban whites than among blacks living in these residence areas. The differences, however, did not appear to be significant. Blacks and whites residing in the open country showed a similar tendency toward increase in visiting relatives. In other words, they did not differ widely in this respect. Although the proportion of elderly persons visiting relatives in the open country and small towns declined, there was no difference by race in either area. Urban blacks, however, were more prone to reduce their visiting of relatives than were urban whites (Table 37).

Summary

The purpose of this study was to determine the nature and extent of involvement of the aged in various types of social and leisure activities. The specific objective was directed toward ascertaining the relationship of selected social and economic factors to the social activity participation of rural older persons as compared with older persons from urban areas.

The study sample included 547 respondents 65 years of age and over and/or retired from work, drawn from two Louisiana parishes. The sampling procedure included the systematic, random selection of persons from lists of aged persons compiled by the Council on Aging of the two parishes. The sampling lists were stratified by residence (rural and urban) and race prior to drawing the actual sample.

The study revealed that the status of the aged persons studied was characterized by low educational attainment, low occupational level, deteriorating health, and inadequate housing. The majority of the older persons included were residentially immobile and tended to live either alone in the household or with only their spouse present. The household composition suggested that many of the elderly respondents were in positions of dependence and subordination while others lived alone. Both of these developments represent a social structural problem of contemporary America. Elderly persons are constrained by cultural practices to remain alone or become unwelcome "guests" in their later years of life.

The expectation that social activities of the aged respondents studied would vary greatly was moderately supported. Although older persons as a whole participated in a variety of social activities, they were involved mainly in low physical demanding, informal home centered activities, including watching television or radio listening, house or yard work, visiting friends or relatives, and telephone conversations. Other activities in which the aged participated to a much lesser degree were parties or celebrations, card games, outdoor recreation, hobbies, reading, and traveling.

Discontinuity or decline was relatively high for such activities as moviegoing, parties or celebrations, outdoor recreation, traveling, card games, and shopping. Watching television or radio listening, telephone conversations, and reading showed the lowest amount of discontinuity and were the only activities where increases in participation by the sample exceeded decreases.

The second expectation—that nature and extent of change in social activities would vary by rural and urban residence—was partially supported. Watching television or listening to the radio and house or yard work were found to be engaged in to a significant degree by both rural and urban older persons. The least popular activities for both rural and urban older persons were moviegoing, card games, parties or celebrations, outdoor recreation, and hobbies. Watching television or radio listening and telephone conversations were found to be popular activities among both rural and urban older persons. However, the high level of participation in this type of activity was attributed more to the rural elderly respondents than to urban elderly respondents. All elderly persons experienced severe declines in social activities.

One difference found was that the rural aged tended to visit friends and watch television or listen to the radio to a greater extent than did their urban counterparts.

Although both rural and urban older persons experienced a significant decline in most social activities, a greater decline occurred among the rural aged than among the urban aged. This was especially true for such activities as visiting relatives, gardening, traveling, and hobbies. The urban aged, however, tended to become less involved in reading, visiting friends, and shopping than the rural aged. Although the above rural-urban differences are of interest, it is important to point out that older persons as a whole tended toward homogeneity of social activities regardless of their place of residence.

The third expectation was that social activity participation of rural and urban aged persons would vary by sex, income, education, and race. The results of the test of this expectation were mixed and are summarized below.

Sex

(1) Both males and females of all residence groups were found to be engaged significantly in watching television or radio listening. The greatest decline occurred for open country males.

(2) Urban females participated more in reading than urban males, and rural open country males participated more in this activity than open country females.

(3) Females were involved in telephone conversations more than males, especially in small towns and urban areas.

(4) Males and females of the open country and small towns were more active in visiting friends. The decline in this activity was greater for males and females of the open country and small towns than for those of urban areas.

(5) Females became much less active in church work, as a whole, than did males, in all residence groups.

(6) Females of the open country and small towns were more active in visiting relatives than were males, while the opposite was true in urban areas. The decline in this activity was greater for females of the open country, and least for females of urban areas.

Income

(1) Low income older persons of small towns were involved more in television watching and radio listening than were those of the open country or urban areas. The smallest increase in this activity occurred among low income older persons of the open country, while the largest increase occurred among small town and urban older persons.

(2) Older persons with higher incomes increased their reading more than lower income persons in all three residence groups; however, the increase was greater for urban older persons.

(3) Higher income persons were more involved in telephone conversations than lower income persons in each residence group. The involvement was greater for higher income persons of small towns. The greatest decline in this activity occurred among higher income urban persons, while the least decline occurred among higher income persons of small towns.

(4) Higher income older persons of the open country and small towns were found to participate more in visiting friends than lower income persons.

(5) Church work declined among older persons of the sample regardless of income level or place of residence. However, the more affluent urban and open

country dwellers increased their church work more than all classes of lower income older persons.

(6) Visiting relatives declined more for the higher income elderly of the open country and urban areas and less for higher income small town elderly persons.

Education

It was evident that even though educational level had some influence on social activity participation, the influence was not very great for older persons regardless of residence. This was especially true for watching television or listening to the radio, and for telephone conversations. However, the more highly educated did more reading upon becoming aged than did those of lower education.

Race

(1) No differences in any of the residence groups existed for watching television or listening to the radio. Watching television or listening to the radio, however, was more popular among blacks and whites of small towns than among those in the open country or urban areas.

(2) Whites of the urban and open country areas reported slightly more reading than did blacks of the same areas. Blacks of small towns showed a slightly higher tendency toward reading than did whites of the same area.

(3) A large proportion of the elderly respondents of all residence categories reported having never engaged in telephone conversations, and the proportion was higher for blacks than for whites.

(4) Visiting friends declined more among blacks than among whites, and the differences were greater in the open country than in small towns or urban areas.

(5) Church work was more popular among blacks than among whites, especially in small towns. Declines in church work were similar for blacks and whites in all three residence categories, with urban blacks showing a slightly greater decline than urban whites.

(6) Finally, visiting relatives increased slightly more among small town and urban whites than among blacks of the same areas.

Conclusions

As persons become aged, the social activities in which they participate become more similar in type. This does not mean that the aged are a homogeneous group, but rather that they suffer from common problems of poor health, reduced income, and occupational retirement and thus become less active in terms of social participation. Because of these problems and others, the aged are not fully able to cope with life in general.

The decline in social activities was slightly greater for the rural aged than for the urban aged. This indicates that rural older persons are probably more prone to become inactive than are urban older persons. This may also mean that rural older persons have less access to social and recreational facilities than urban older persons. This is a matter that should be considered in the development of leisure and recreational programs for the aged.

The severe reduction in participation in social activities is a reality among the aged. This may be related not only to health problems but also to low socioeconomic status, lack of status resources (income, occupation), and lack of development of ways in which the time of elderly persons may be occupied with meaningful activities and roles. The increase in home centered, low interactional activities such as watching television or listening to the radio and reading suggests that social programs for the aged should be planned for the home as well as for community or institutional settings.

Income level and educational level should be taken into consideration when planning social programs for the aged. Sex and race, although appearing to be somewhat less important in regard to social activity participation, should also be considered. Although participation in many activities does not vary by sex or race, there are some instances in which it does. The sex and racial composition of the community or institutional setting is also a factor to be considered.

APPENDIX

Table 14.–Watch tv or listen to radio by sex and residence

Response Level	Open Country				Small Town				Urban				Total	
	Male		Female		Male		Female		Male		Female			
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Less	6	(10.0)	12	(17.4)	12	(15.2)	17	(14.2)	19	(20.4)	26	(21.0)	92	(16.8)
Same	20	(33.3)	21	(30.4)	17	(21.5)	32	(26.7)	27	(29.0)	29	(23.4)	146	(26.8)
More	29	(48.3)	33	(47.8)	47	(59.5)	71	(59.2)	44	(47.3)	68	(54.8)	292	(53.6)
Never	5	(8.4)	3	(4.4)	3	(3.8)	0	(0.0)	3	(3.3)	1	(0.8)	15	(2.8)
TOTAL	60	(100.0)	69	(100.0)	79	(100.0)	120	(100.0)	93	(100.0)	124	(100.0)	545	(100.0)

Table 15.–Reading by sex and residence

Response Level	Open Country				Small Town				Urban				Total	
	Male		Female		Male		Female		Male		Female			
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Less	7	(11.5)	20	(29.9)	11	(12.8)	33	(27.7)	27	(29.0)	37	(29.8)	134	(24.7)
Same	12	(19.7)	11	(16.4)	8	(10.3)	21	(17.7)	17	(18.3)	21	(16.9)	90	(16.6)
More	18	(29.5)	12	(19.4)	22	(28.2)	32	(26.9)	20	(21.5)	40	(32.3)	145	(26.8)
Never	24	(39.3)	23	(34.3)	38	(48.7)	33	(27.7)	29	(31.2)	26	(21.0)	173	(31.9)
TOTAL	61	(100.0)	67	(100.0)	78	(100.0)	119	(100.0)	93	(100.0)	124	(100.0)	542	(100.0)

Table 16.–Telephone conversations by sex and residence

Response Level	Open Country				Small Town				Urban				Total	
	Male		Female		Male		Female		Male		Female			
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Less	11	(18.0)	13	(18.8)	14	(18.2)	24	(20.0)	26	(28.0)	33	(27.1)	121	(22.3)
Same	23	(37.7)	20	(29.0)	29	(37.7)	48	(40.0)	37	(39.8)	37	(30.3)	194	(35.8)
More	11	(18.0)	13	(18.8)	16	(20.8)	36	(30.0)	15	(16.1)	46	(37.7)	137	(25.3)
Never	16	(26.3)	23	(33.4)	18	(23.4)	12	(10.0)	15	(16.1)	6	(4.9)	90	(16.6)
TOTAL	61	(100.0)	69	(100.0)	77	(100.0)	120	(100.0)	93	(100.0)	122	(100.0)	542	(100.0)

Table 17.–Visiting friends by sex and residence

	Open Country				Small Town				Urban				Total	
	Male		Female		Male		Female		Male		Female			
Response Level	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Less	23	(37.7)	42	(60.9)	24	(30.0)	65	(54.2)	37	(39.8)	57	(46.0)	248	(45.3)
Same	16	(26.2)	14	(20.3)	18	(22.5)	24	(20.0)	33	(35.5)	30	(24.2)	135	(24.7)
More	19	(31.2)	11	(15.9)	34	(42.5)	30	(25.0)	22	(23.6)	32	(25.8)	148	(27.1)
Never	3	(4.9)	2	(2.9)	4	(5.0)	1	(0.8)	1	(1.1)	5	(4.0)	16	(2.9)
TOTAL	61	(100.0)	69	(100.0)	80	(100.0)	93	(100.0)	93	(100.0)	124	(100.0)	547	(100.0)

Table 18.–Church work by sex and residence

	Open Country				Small Town				Urban				Total	
	Male		Female		Male		Female		Male		Female			
Response Level	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Less	12	(19.7)	33	(47.8)	22	(27.9)	48	(40.6)	26	(28.5)	60	(48.4)	201	(37.1)
Same	18	(29.5)	9	(13.0)	17	(21.5)	27	(22.9)	28	(30.8)	23	(18.5)	122	(22.5)
More	11	(18.0)	13	(18.9)	11	(13.9)	20	(17.0)	17	(18.7)	28	(22.6)	100	(18.5)
Never	20	(32.8)	14	(20.3)	29	(36.7)	23	(19.5)	20	(22.0)	13	(10.5)	119	(21.9)
TOTAL	61	(100.0)	69	(100.0)	79	(100.0)	118	(100.0)	91	(100.0)	124	(100.0)	542	(100.0)

Table 19.–Visiting relatives by sex and residence

	Open Country				Small Town				Urban				Total	
	Male		Female		Male		Female		Male		Female			
Response Level	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Less	39	(47.6)	42	(61.8)	33	(41.8)	63	(52.9)	36	(39.1)	51	(41.1)	254	(46.8)
Same	13	(21.3)	12	(17.7)	21	(26.6)	32	(26.9)	32	(34.8)	33	(26.6)	143	(26.3)
More	16	(26.2)	12	(17.7)	22	(27.8)	22	(18.5)	22	(23.9)	34	(27.4)	128	(23.6)
Never	3	(4.9)	2	(2.8)	3	(3.8)	2	(1.7)	2	(2.2)	6	(4.9)	18	(3.3)
TOTAL	61	(100.0)	68	(100.0)	79	(100.0)	119	(100.0)	92	(100.0)	124	(100.0)	543	(100.0)

Table 20.–Watch tv or listen to radio by income and residence

	Low Income ($0-5,999)						High Income ($6,000 and over)					
	Open Country		Small Town		Urban		Open Country		Small Town		Urban	
Response Level	N	%	N	%	N	%	N	%	N	%	N	%
Less	15	(12.7)	27	(15.7)	38	(22.4)	3	(30.0)	2	(7.4)	7	(14.9)
Same	46	(39.0)	40	(23.3)	45	(26.5)	3	(30.0)	9	(33.3)	11	(23.4)
More	50	(42.4)	102	(59.3)	83	(48.8)	4	(40.0)	16	(59.3)	29	(61.7)
Never	7	(5.9)	3	(1.7)	4	(2.3)	0	(0.0)	0	(0.0)	0	(0.0)
TOTAL	118	(100.0)	172	(100.0)	170	(100.0)	10	(100.0)	27	(100.0)	47	(100.0)

Table 21.–Reading by income and residence

	Low Income ($0-5,999)						High Income($6,000 and over)					
	Open Country		Small Town		Urban		Open Country		Small Town		Urban	
Response Level	N	%	N	%	N	%	N	%	N	%	N	%
Less	26	(22.0)	37	(21.6)	55	(32.4)	2	(20.0)	6	(23.1)	9	(19.2)
Same	11	(9.3)	20	(11.7)	23	(13.5)	4	(40.0)	9	(34.6)	15	(31.9)
More	28	(23.8)	46	(26.9)	39	(22.9)	3	(30.0)	8	(30.8)	21	(44.7)
Never	53	(44.9)	68	(39.8)	53	(31.2)	1	(10.0)	3	(11.5)	2	(4.2)
TOTAL	118	(100.0)	171	(100.0)	170	(100.0)	10	(100.0)	26	(100.0)	47	(100.0)

Table 22.–Telephone conversations by income and residence

	Low Income ($0-5,999)						High Income ($6,000 and over)					
	Open Country		Small Town		Urban		Open Country		Small Town		Urban	
Response Level	N	%	N	%	N	%	N	%	N	%	N	%
Less	22	(18.3)	36	(21.1)	44	(26.2)	2	(20.0)	2	(7.7)	15	(31.9)
Same	39	(32.5)	66	(38.6)	60	(35.7)	4	(40.0)	11	(42.3)	14	(29.8)
More	22	(18.3)	42	(24.5)	46	(27.4)	2	(20.0)	10	(38.5)	15	(31.9)
Never	37	(30.9)	27	(15.8)	18	(10.7)	2	(20.0)	3	(11.5)	3	(6.4)
TOTAL	120	(100.0)	171	(100.0)	168	(100.0)	10	(100.0)	26	(100.0)	47	(100.0)

Table 23.–Visiting friends by income and residence

	Low Income ($0-5,999)						High Income ($6,000 and over)					
	Open Country		Small Town		Urban		Open Country		Small Town		Urban	
Response Level	N	%	N	%	N	%	N	%	N	%	N	%
Less	62	(51.7)	80	(46.5)	77	(45.3)	3	(30.0)	9	(33.3)	17	(36.2)
Same	27	(22.5)	36	(20.9)	48	(28.2)	3	(30.0)	6	(22.2)	15	(31.9)
More	26	(21.7)	53	(30.8)	40	(23.5)	4	(40.0)	11	(40.8)	14	(29.8)
Never	5	(4.1)	3	(1.8)	5	(3.0)	0	(0.0)	1	(3.7)	1	(2.1)
TOTAL	120	(100.0)	172	(100.0)	170	(100.0)	10	(100.0)	27	(100.0)	47	(100.0)

Table 24.–Church work by income and residence

	Low Income ($0-5,999)						High Income ($6,000 and over)					
	Open Country		Small Town		Urban		Open Country		Small Town		Urban	
Response Level	N	%	N	%	N	%	N	%	N	%	N	%
Less	41	(34.2)	64	(37.4)	73	(43.0)	4	(40.0)	6	(23.1)	13	(28.9)
Same	24	(20.0)	35	(20.5)	40	(23.5)	3	(30.0)	9	(34.6)	11	(24.4)
More	21	(17.5)	26	(15.2)	32	(18.8)	3	(30.0)	5	(19.2)	13	(28.9)
Never	34	(28.3)	46	(26.9)	25	(14.7)	0	(0.0)	6	(23.1)	8	(17.8)
TOTAL	120	(100.0)	171	(100.0)	170	(100.0)	10		26	(100.0)	45	(100.0)

Table 25.–Visiting relatives by income and residence

	Low Income ($0-5,999)						High Income ($6,000 and over)					
	Open Country		Small Town		Urban		Open Country		Small Town		Urban	
Response Level	N	%	N	%	N	%	N	%	N	%	N	%
Less	66	(60.6)	90	(52.3)	74	(43.8)	5	(50.0)	6	(23.1)	13	(27.7)
Same	14	(12.8)	45	(26.2)	45	(26.6)	1	(10.0)	8	(30.8)	20	(42.5)
More	24	(22.0)	33	(19.2)	44	(26.0)	4	(40.0)	11	(42.3)	12	(25.5)
Never	5	(4.6)	4	(2.3)	6	(3.6)	0	(0.0)	1	(3.8)	2	(4.3)
TOTAL	109	(100.0)	172	(100.0)	169	(100.0)	10	(100.0)	26	(100.0)	47	(100.0)

Table 26.–Watch tv or listen to radio by education and residence

Response Level	Open Country Education				Small Town Education				Urban Education			
	Low (0-11)		High (12 and over)		Low (0-11)		High (12 and over)		Low (0-11)		High (12 and over)	
	N	%	N	%	N	%	N	%	N	%	N	%
Less	15	(12.8)	4	(33.4)	26	(16.3)	3	(7.5)	34	(22.2)	11	(10.5)
Same	40	(34.2)	1	(8.3)	34	(21.4)	15	(37.5)	42	(27.5)	14	(13.3)
More	56	(47.7)	6	(50.0)	96	(60.4)	22	(55.0)	73	(47.7)	39	(37.1)
Never	6	(5.1)	1	(8.3)	3	(1.9)	0	(0.0)	4	(2.6)	41	(39.1)
TOTAL	117	(100.0)	12	(100.0)	159	(100.0)	40	(100.0)	153	(100.0)	105	(100.0)

Table 27.–Reading by education and residence

Response Level	Open Country Education				Small Town Education				Urban Education			
	Low (0-11)		High (12 & over)		Low (0-11)		High (12 & over)		Low (0-11)		High (12 & over)	
	N	%	N	%	N	%	N	%	N	%	N	%
Less	24	(20.5)	4	(16.6)	33	(20.9)	10	(25.7)	51	(33.3)	13	(20.3)
Same	12	(10.3)	3	(12.5)	18	(11.4)	11	(28.2)	22	(14.4)	16	(25.0)
More	27	(23.1)	4	(16.6)	36	(22.7)	18	(46.1)	26	(17.0)	34	(53.1)
Never	54	(46.1)	13	(54.3)	71	(44.9)	0	(0.0)	54	(35.3)	1	(1.6)
TOTAL	117	(100.0)	24	(100.0)	158	(100.0)	39	(100.0)	153	(100.0)	64	(100.0)

Table 28.–Telephone conversations by education and residence

Response Level	Open Country Education				Small Town Education				Urban Education			
	Low (0-11)		High (12 & over)		Low (0-11)		High (12 & over)		Low (0-11)		High (12 & over)	
	N	%	N	%	N	%	N	%	N	%	N	%
Less	20	(16.8)	4	(36.4)	30	(19.0)	8	(21.5)	40	(26.5)	19	(29.7)
Same	38	(31.9)	5	(45.4)	62	(39.2)	15	(38.5)	55	(36.4)	19	(29.7)
More	23	(19.4)	1	(9.1)	39	(24.7)	13	(33.3)	39	(25.8)	22	(34.4)
Never	38	(31.9)	1	(9.1)	27	(17.1)	3	(7.7)	17	(11.3)	4	(6.2)
TOTAL	119	(100.0)	11	(100.0)	158	(100.0)	39	(100.0)	151	(100.0)	64	(100.0)

Table 29.–Visiting friends by education and residence

	Open Country Education				Small Town Education				Urban Education			
	Low (0-11)		High (12 & over)		Low (0-11)		High (12 & over)		Low (0-11)		High (12 & over)	
Response Level	N	%	N	%	N	%	N	%	N	%	N	%
Less	60	(50.4)	5	(22.7)	77	(48.4)	12	(30.0)	71	(46.4)	23	(35.9)
Same	28	(23.5)	2	(9.1)	33	(20.8)	9	(22.5)	46	(30.1)	17	(26.6)
More	26	(21.9)	4	(18.2)	45	(28.3)	19	(47.5)	31	(20.2)	23	(35.9)
Never	5	(4.2)	11	(50.0)	4	(2.5)	0	(0.0)	5	(3.3)	1	(1.6)
TOTAL	119	(100.0)	22	(100.0)	159	(100.0)	40	(100.0)	153	(100.0)	64	(100.0)

Table 30.–Church work by education and residence

	Open Country Education				Small Town Education				Urban Education			
	Low (0-11)		High (12 & over)		Low (0-11)		High (12 & over)		Low (0-11)		High (12 & over)	
Response Level	N	%	N	%	N	%	N	%	N	%	N	%
Less	41	(34.5)	4	(23.5)	61	(38.6)	9	(23.1)	65	(42.8)	21	(33.3)
Same	23	(19.3)	4	(23.5)	33	(20.9)	11	(28.2)	36	(23.7)	15	(23.8)
More	22	(18.5)	2	(11.8)	19	(12.0)	12	(30.8)	25	(16.4)	20	(31.8)
Never	33	(27.7)	7	(41.2)	45	(28.5)	7	(17.9)	26	(17.1)	7	(11.1)
TOTAL	119	(100.0)	17	(100.0)	158	(100.0)	39	(100.0)	152	(100.0)	63	(100.0)

Table 31.–Visiting relatives by education and residence

	Open Country Education				Small Town Education				Urban Education			
	Low (0-11)		High (12 & over)		Low (0-11)		High (12 & over)		Low (0-11)		High (12 & over)	
Response Level	N	%	N	%	N	%	N	%	N	%	N	%
Less	66	(55.4)	5	(45.4)	84	(52.8)	12	(30.8)	72	(47.4)	15	(23.4)
Same	24	(20.2)	1	(9.1)	42	(26.4)	11	(28.2)	43	(28.3)	22	(34.4)
More	24	(20.2)	4	(36.4)	28	(17.6)	16	(41.0)	31	(20.4)	25	(39.1)
Never	5	(4.2)	1	(9.1)	5	(3.2)	0	(0.0)	6	(3.9)	2	(3.1)
TOTAL	119	(100.0)	11	(100.0)	159	(100.0)	39	(100.0)	152	(100.0)	64	(100.0)

Table 32.–Watch tv or listen to radio by color and residence

	Response Level				
	Never	Less	Same	More	Total
Open Country					
Black	3(5.8)	7(13.5)	16(30.8)	26(50.0)	52(100.1)
White	5(6.5)	11(14.3)	25(32.5)	36(46.8)	77(100.1)
Small Town					
Black	2(2.4)	15(18.1)	16(19.3)	50(60.2)	83(100.0)
White	1(0.9)	14(12.1)	33(28.4)	68(58.6)	116(100.0)
Urban					
Black	3(3.3)	21(23.3)	18(20.0)	48(53.3)	90(99.9)
White	1(0.8)	24(18.9)	38(29.9)	64(50.4)	127(100.0)

Table 33.-Reading by color and residence

	Response Level				
	Never	Less	Same	More	Total
Open Country					
Black	29(55.8)	12(23.1)	2(3.8)	9(17.3)	52(100.0)
White	18(23.7)	15(19.7)	21(27.6)	22(28.9)	76(99.9)
Small Town					
Black	33(39.8)	15(18.1)	11(13.2)	24(28.9)	83(100.0)
White	38(33.3)	28(24.6)	18(15.8)	30(26.3)	114(100.0)
Urban					
Black	39(43.3)	28(31.1)	11(12.2)	12(13.3)	90(99.9)
White	16(12.6)	36(28.3)	27(21.3)	48(37.8)	127(100.0)

Table 34.–Telephone conversations by color and residence

	Response Level				
	Never	Less	Same	More	Total
Open Country					
Black	25(47.2)	8(15.1)	11(20.8)	9(17.0)	53(100.1)
White	14(18.2)	16(20.8)	32(41.6)	15(19.5)	77(100.1)
Small Town					
Black	17(20.5)	18(21.7)	22(26.5)	26(31.3)	83(100.0)
White	13(11.4)	20(17.5)	55(48.2)	26(22.8)	114(99.9)
Urban					
Black	13(16.4)	19(24.0)	28(35.4)	19(24.0)	79(99.8)
White	8(6.3)	30(23.8)	46(36.5)	42(33.3)	126(99.9)

Table 35.–Church work by color and residence

	Response Level				
	Never	Less	Same	Moew	Total
Open Country					
Black	15(28.3)	19(35.8)	8(15.1)	11(20.8)	53(100.0)
White	19(24.7)	26(33.8)	19(24.7)	13(16.4)	77(100.1)
Small Town					
Black	8(9.8)	29(35.4)	24(29.3)	21(25.6)	82(100.1)
White	44(38.3)	41(35.6)	20(17.4)	10(8.7)	115(100.0)
Urban					
Black	11(12.2)	38(42.2)	19(21.1)	22(24.4)	90(99.9)
White	22(17.6)	48(38.4)	32(25.6)	23(18.4)	125(100.0)

Table 36.–Visiting friends by color and residence

	Response Level				
	Never	Less	Same	More	Total
Open Country					
Black	1(1.9)	31(59.6)	6(11.5)	14(26.9)	53(99.9)
White	3(3.9)	34(44.2)	24(31.2)	16(20.8)	77(100.1)
Small Town					
Black	1(1.2)	41(49.4)	16(19.3)	25(30.1)	83(100.0)
White	4(3.4)	48(41.0)	26(22.2)	39(33.3)	117(99.9)
Urban					
Black	3(3.3)	42(46.7)	28(31.1)	17(18.9)	90(100.0)
White	3(2.4)	52(40.9)	35(27.6)	37(29.1)	127(100.0)

Table 37.–Visiting relatives by color and residence

	Response Level				
	Never	Less	Same	More	Total
Open Country					
Black	1(1.9)	29(55.8)	11(21.2)	11(21.2)	52(100.1)
White	4(5.2)	42(54.5)	14(18.2)	17(22.1)	77(100.0)
Small Town					
Black	1(1.2)	39(47.6)	26(31.7)	16(19.5)	82(100.0)
White	4(3.4)	57(49.1)	27(23.3)	28(24.1)	116(99.9)
Urban					
Black	5(5.6)	42(47.2)	22(24.7)	20(22.5)	89(100.0)
White	3(2.4)	45(35.4)	43(33.8)	36(28.3)	127(99.9)

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Residential and Racial Trends For the School-Age Population And Public School Teachers in Louisiana

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Appendix 32

Residential and Racial Trends for the School-Age Population and Public School Teachers in Louisiana

William W. Falk and Allen Comfort*

Introduction

This study is largely a longitudinal follow-up of earlier work by Smith[1] and Smith and Bertrand.[2] Their studies dealt with trends and patterns in Louisiana education from 1936 to 1960. Our study will serve to update theirs and at the same time will suggest an alternative approach to the solution of methodological problems encountered. The focus is on rural parishes since they most often lag behind urban parishes in terms of average years of educational attainment, teacher salaries, etc.

Educational attainment in Louisiana has historically been poor, especially when compared with that in other states (for example, in a national ranking of literacy rates using 1970 census data, Louisiana was ranked 50th[3]). In this report the focus is not on a comparative analysis of Louisiana with other states; rather, the central interest is on variation within the state itself. In particular, we wish to examine two segments of the population that have tended to be sharply different — rural and urban. Whites and nonwhites within those parishes classified as rural or urban will also be studied.

Rationale of the Study

One primary factor provided the impetus for this study. For several decades there has been a seemingly irreversible trend in America — the migration from rural to urban areas. Those writing about rural areas often referred to their populace as those "left behind."[4] At the same time,

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[1] Marion B. Smith, *A Sociological Analysis of Rural Education in Louisiana,* Baton Rouge: Louisiana State University Press, 1938.

[2] Marion B. Smith and Alvin L. Bertrand, *Rural Education in Transition: A Study of Trends and Patterns in Louisiana,* Louisiana Agricultural Experiment Station, Bulletin No. 576, December, 1963.

[3] This data is from Public Affairs Research Council, *PAR Analysis, Educational Attainment in Louisiana,* No. 188, February, 1973. Also reported was Louisiana's ranking of 41st in the median years of education completed by adults 25 years old or older (10.8 years). Louisiana ranked 50th in the proportion of adults with no schooling (3.9%); 50th for the proportion of adults with 5 years or less of schooling—the "functionally illiterate" (13.1%); 41st in the proportion of adults who have finished high school (42.3%)—the criterion considered by many to be the minimum requirements for an adequate education in the 1970's; and 35th in the proportion of adults who have finished college (9.1%).

[4] See the report by the President's National Advisory Commission on Rural Poverty, "The People Left Behind." Washington, D.C., U.S. Government Printing Office (September, 1967).

increasing urbanization has seen a concomitant trend on the part of researchers to largely ignore rural areas. Some have actually written about urban areas (and their attendant problems) as though there were no others. This myopic focus has led to a wealth of information on urban phenomena, but a paucity of comparable information on rural phenomena.

As Beale has recently shown,[5] the longstanding trend of rural-to-urban migration seems to have reached a turning point. Not only has the trend abated but it has reversed. We may now speak of urban-to-rural migration as a trend of the future. Rural areas are also retaining more of their indigenous population at the same time that they are attracting new residents. Additionally, in the U.S. we seem to have reached an historical juncture when food and fiber production is no longer to be taken for granted. Because of these developments, rural areas are more and more in the news, both as places to live and for their economic and sustenance functions. It seems reasonable to expect, then, that rural areas will be under increasing demand to provide high quality services for rural residents. And, if past history is any indication, education will be one of those services for which many people will have high expectations.

Education in rural areas will remain important for at least two reasons. First, since food and fiber production is becoming increasingly mechanized and technological, it will be necessary to provide the experiences and skills requisite to competing in what will become an evermore competitive labor market. This labor market will seek persons both in agricultural jobs (e.g., farmers, operators of farm equipment, etc.) and in jobs which are agriculturally-supportive, that is, which serve rural residents (e.g., agricultural banking and finance, soil science, agricultural production, parks and recreation planning, etc.). Second, for many persons, the educational facilities available in a community are a key consideration in the choosing of a residence.[6] There is (and will likely continue to be) a mutual ''push-pull'' dialectic in leaving urban-suburban areas for rural areas. One factor is a sense of escaping urban problems in a move to less troubled rural areas (both a push and pull factor). At the same time there is a desire to have available certain services which are comparable in quality to those just vacated: in short, to not feel that one's children will be placed at a disadvantage later on due to poor educational facilities.

The time has come when more information must be generated on rural folk, rural institutions, and rural areas. With reversed migration streams and an increasingly technological agriculture, educational systems in rural areas are likely to have high demands placed upon them. Using the U. S. Census and the Annual Reports for the State Department of Education as data sources, it is possible to do a systematic assessment of various factors related to education in the state of Louisiana.

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[5] Calvin Beale, ''Rural Development: Population and Resettlement,'' *Journal of Soil and Water Resources*, January-February, 1974.

[6] Almost any text on housing will support this statement. For examples, see Glenn H. Beyer, *Housing and Society*. New York: The MacMillan Co., 1965; Nelson N. Foote et al., *Housing Choice and Housing Constraints*. New York: McGraw-Hill, 1960; George Grier and Eunice Grier, *Equality and Beyond*. Chicago: Quadrangle Books, 1966.

Methods and Procedures

As stated earlier, this study builds on the work of Smith, and Smith and Bertrand. Smith was among the early rural sociologists who examined education from a sociological perspective. His later work with Bertrand built on this framework and included an historical analysis of roughly a quarter century of change (1937-1961). As did Smith and Bertrand, the authors of this study have drawn heavily on the U.S. Census[7] and the Annual Reports of the Louisiana State Department of Education.[8]

Whereas Smith and Bertrand used Smith's earlier work in 1937 as a benchmark and then used as comparative dates 1950 and 1960, the present study has used 1950, 1960, and 1970 (for school data, 1974). The year 1950 was a key one for Louisiana because it was the first year in which the census indicated that a majority of the citizenry resided in urban areas. Following the lead of Smith and Bertrand, it was decided to dichotomize urban and rural parishes. While Smith and Bertrand chose to operationalize the "most urban" parishes as 65 percent urban or more and "most rural" parishes as 75 percent rural or more in 1950, we chose to use 65 percent in both cases since this would standardize our comparative framework. Additionally, while they used the same parishes at all three points in time based on the 1950 classification, our number of parishes varies. It was found that certain "most rural" parishes in 1950 were no longer 65 percent rural in 1960; in fact, one parish (St. Bernard) went from the most rural category to the most urban category between 1950 and 1960 and was the third most urban parish in Louisiana in 1970. The method used was meant to reduce potential interpretation error caused by the inclusion of parishes at a point in time when they were not actually "most rural" or "most urban" as the case might be.

The report is organized so that summary data are first presented on the rural and urban population for 1950, 1960, and 1970, on the school-age population (7-17 years old), and on the school-age population actually enrolled in school. Data are also presented on teacher training and teacher experience for the schools in rural and urban parishes. In almost all cases the data are presented by both residence and race. The final section of the report is included to discuss the implications of selected findings which seem of interest.

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[7] Census data in this report are from the United States Census of Population, for the years 1950, 1960, and 1970, U.S. Department of Commerce, Bureau of the Census.

[8] School data in this report are from the State Department of Education of Louisiana, *One Hundred Second Annual Report for the Session 1950-51; One Hundred Twelfth Annual Report for the Session 1960-61;* and *One Hundred Twenty-Fifth Annual Report for the Session 1973-74.*

Population Trends in Louisiana: 1950-1970

State Population Trends

Since our goal was to examine education in an historical manner, data were aggregated from the 1950, 1960, and 1970 censuses. These data show the dramatic population shifts which occurred within the state over a period of 20 years. The total population increased from 2,683,516 in 1950 to 3,257,022 in 1960 to 3,643,180 in 1970 (Figure 1; and Table 1 in the Appendix). Between 1950 and 1970 the state's population increased by 959,664, a gain of 35.8 percent.[9] The white populace grew at a rate of 41.5 percent (from 1,796,683 in 1950 to 2,541,498 in 1970) whereas the nonwhite populace grew at a rate of 24.0 percent (from 886,833 in 1950 to 1,099,808 in 1970).[10] The white-to-nonwhite ratio remained quite constant, with whites comprising 67.0 percent of the total population in 1950, 67.9 percent in 1960, and 69.8 percent in 1970.

Rural-Urban Population Trends

In 1950, for the first time, the majority of Louisianians were classified as urban dwellers (54.8 percent), while the remaining 45.2 percent of the people in the state were classified as residing in rural farm and rural nonfarm areas. By 1960 the urban population had increased to 63.3 percent of the state population, while the rural population had decreased to 36.7 percent. Again in 1970 an increase was noted for the urban population (to 66.1 percent) with another decrease in the rural population (to 33.9 percent). Between 1950 and 1970, the urban population increased from 1,471,696 persons to 2,406,150 persons—a growth rate of 63.5 percent. The rural population, on the other hand, barely remained constant with a slight increase from 1,211,820 in 1950 to 1,233,384 in 1970. It is especially interesting to note that between 1950 and 1970 rural farm residents decreased by nearly half a million people (453,698, or 80 percent) while the rural nonfarm population was increasing by nearly an equal amount (474,262, or 73.6 percent). Whereas the rural farm population was 21.2 percent of the total state population in 1950, it had dropped to only 3.1 percent by 1970 (an actual loss of 453,698 persons). But the rural nonfarm

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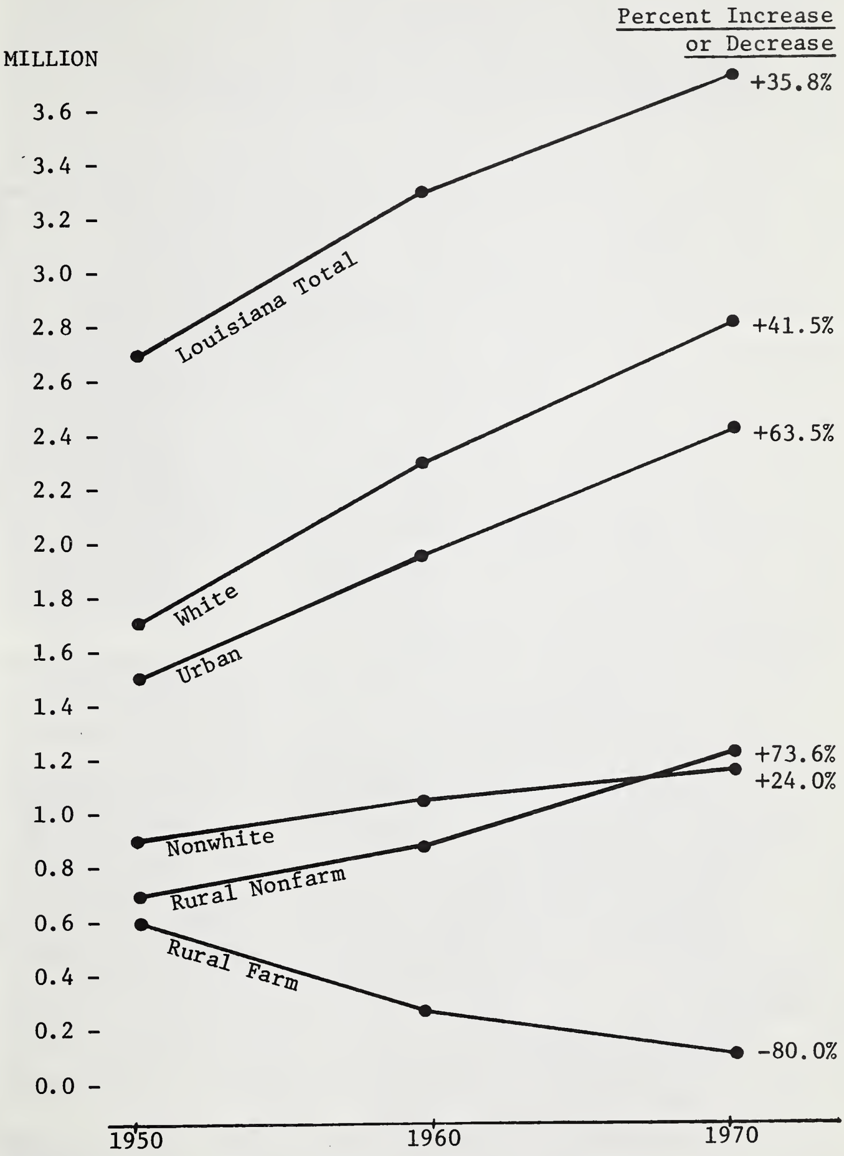
[9] The total 1950 population was used as the base figure for calculating the percent increase of the population. The *net change* in population from 1950 to 1970 was divided by the *total* population of 1950, thereby giving the percent increase in population during the 20-year period. Further, 1950 was used as the base year in calculating all other percent increases and decreases reported in this paper.

[10] The terms "white" and "nonwhite" are used to maintain the distinction used by Smith and Bertrand. Since much of the information for this study was gathered from tables listing data as white or Negro, it was necessary to find the proportion of the state's nonwhite population that is composed of Negroes. In 1950, Negroes comprised 99.5% of the total nonwhite population; in 1960, 99.4% and in 1970, 98.8%. With percentages this high it is acceptable to use the data for Negroes as the data for nonwhites. This will facilitate the ease with which a comparison can be made between our study and the study of Smith and Bertrand.

FIGURE 1

Population Trends in Louisiana, 1950–1970, by Race and Residence



population went from 24.0 percent of the total state population in 1950 to 30.7 percent in 1970. Furthermore, when we analyze the percentage that the rural farm and rural nonfarm population constitutes of the total number of people in the rural classification, we find that the rural farm component was 46.8 percent in 1950, 19.5 percent in 1960, and 9.2 percent in 1970. In short, as a percent of total rural population, the number of people living on farms was decreasing while at the same three points in time the rural nonfarm population was increasing from 53.2 percent to 80.5 percent to 90.7 percent — a rather radical rearrangement of the places of residence of the rural population. In this time period, a consistently greater proportion of the state's population was classified as urban and rural nonfarm, but an increasingly smaller percentage was classified as rural farm.

When we compare the white population and the nonwhite population on the rural and urban dimensions, some differences are noted. In 1950, 56.9 percent of the whites in the state were classified as urban versus 50.6 percent for nonwhites — only a slight difference from the 54.8 percent urban residents for the whole state. By 1960 the percent urban had increased to 64.0 percent for whites and to 61.7 percent for nonwhites; for the state the percentage was 63.3. These percentages increased during the next decade so that by 1970 they were 65.6 percent for whites versus 67.8 percent for nonwhites; for the state the percent urban was 66.1. For both whites and nonwhites there was increasing move to urban residence, although the growth rate between 1950 and 1970 was somewhat smaller for whites (62.9 percent) than for nonwhites (66.1 percent).

Following the procedure used by Smith and Bertrand, a classification of the "most urban" and "most rural" parishes was done. Using a criterion of 65.0 percent or greater for either the rural or urban classification, the number of parishes included in the analysis varies at each point in time (see Figures 2, 3, and 4; and Tables 2 and 3 in the Appendix). Briefly, in 1950, six parishes were "most urban" — Caddo, Calcasieu, East Baton Rouge, Jefferson, Orleans, and Ouachita. By 1960 this number had increased to nine parishes, with the addition of Bossier, Iberia, and St. Bernard. In 1970 there were again nine parishes but the particular parishes changed — Bossier and Iberia dropped out and Lafayette and St. Mary were added. While the number of "most urban" parishes grew between 1950 and 1970, the number of "most rural" parishes got continuously smaller. In 1950, nearly two-thirds of all parishes in the state (i.e., 42 of 64) met the criterion of 65 percent rural; by 1960 this number had decreased to 32 parishes and by 1970 had further decreased to only 27.

It is clear that the most urban parishes have accounted for a very high percentage of the total state population in recent years. The six parishes included as most urban in 1950 made up 43.7 percent of the state population; with nine parishes included this percentage had increased to 51.5 percent by 1960 and to 52.9 percent by 1970. Although 42 parishes were

FIGURE 2

Most Rural and Most Urban Parishes in Louisiana in 1950

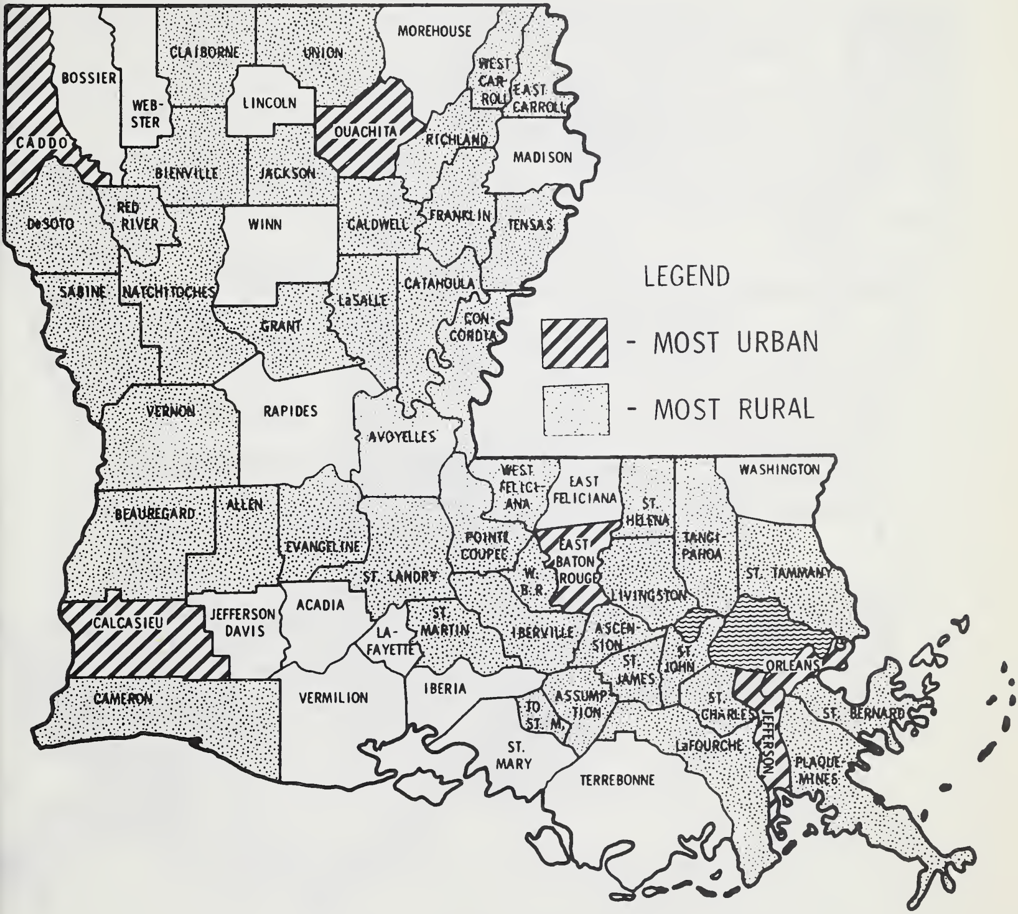


FIGURE 3

Most Rural and Most Urban Parishes in Louisiana in 1960

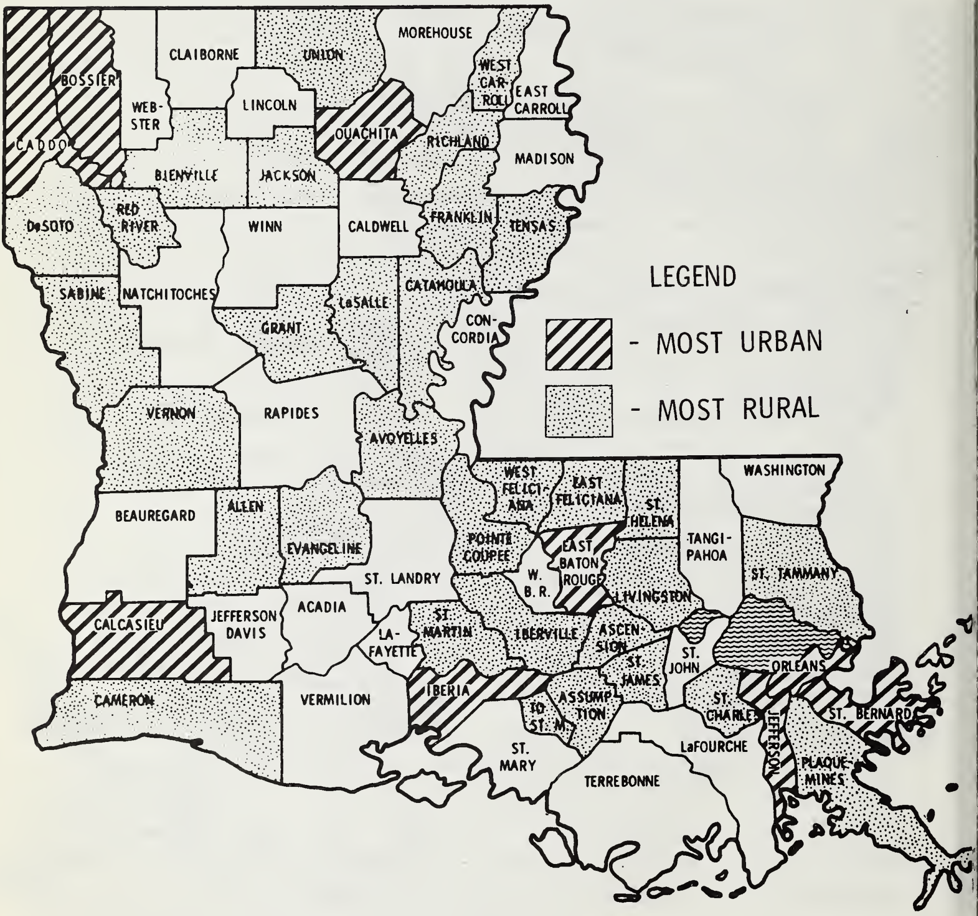
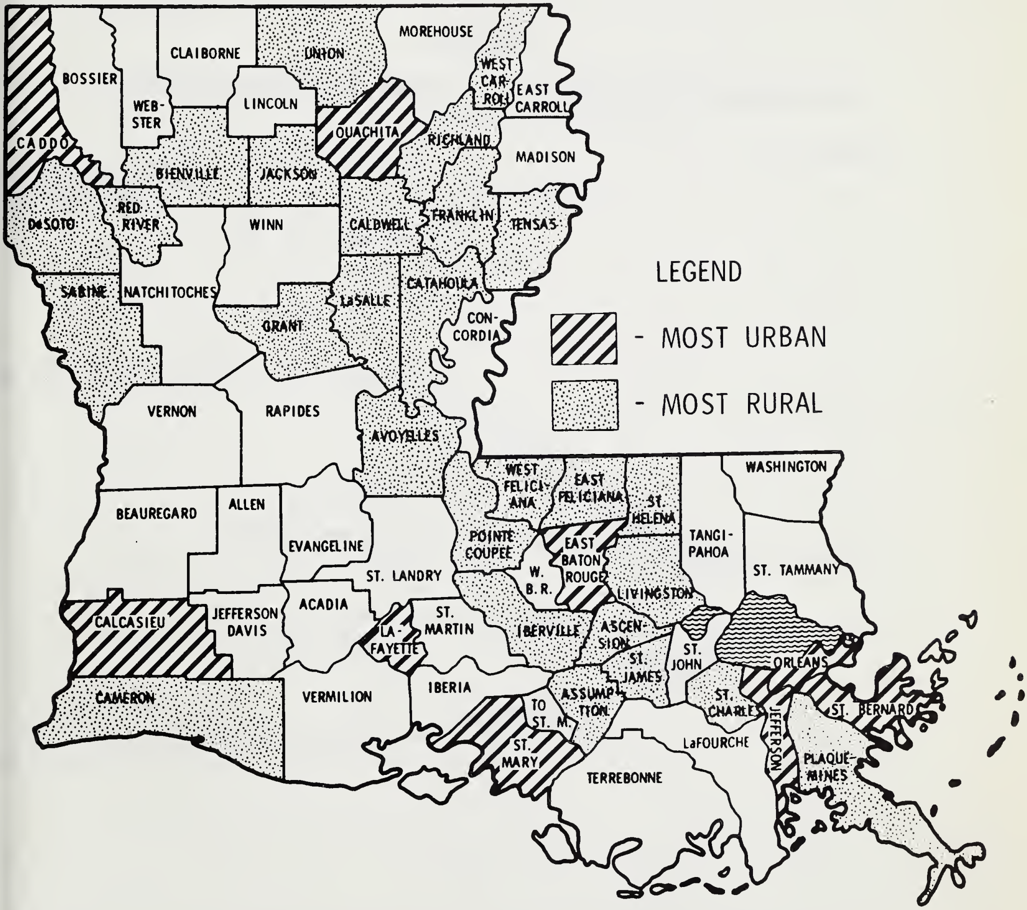


FIGURE 4

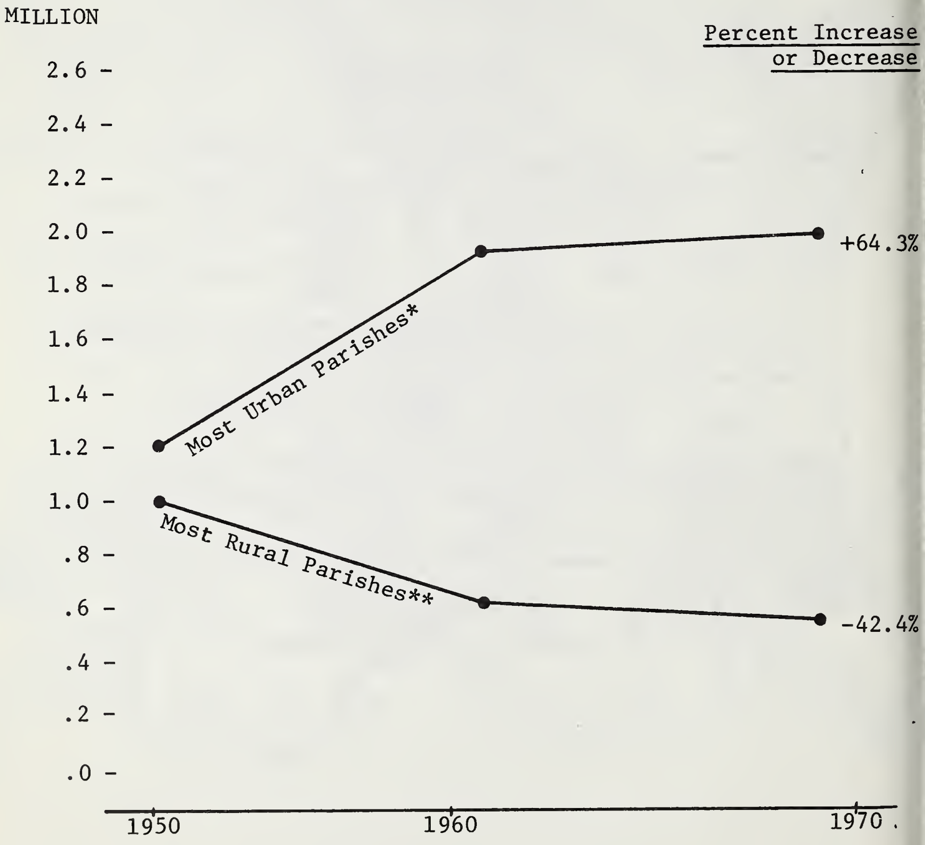
Most Rural and Most Urban Parishes in Louisiana in 1970



included in the most rural category in 1950, they accounted for only 28.0 percent of total state population and this percentage had decreased to 15.7 percent by 1960 (with 32 parishes) and to 11.5 percent by 1970 (with 27 parishes). Between 1950 and 1970, the most urban parishes grew by 64.3 percent (755,031 people) while the most rural parishes decreased by 42.4 percent (384,706 people) (Figure 5; and Table 1 in the Appendix).

FIGURE 5

Population Trends in Most Urban and Most Rural Louisiana Parishes



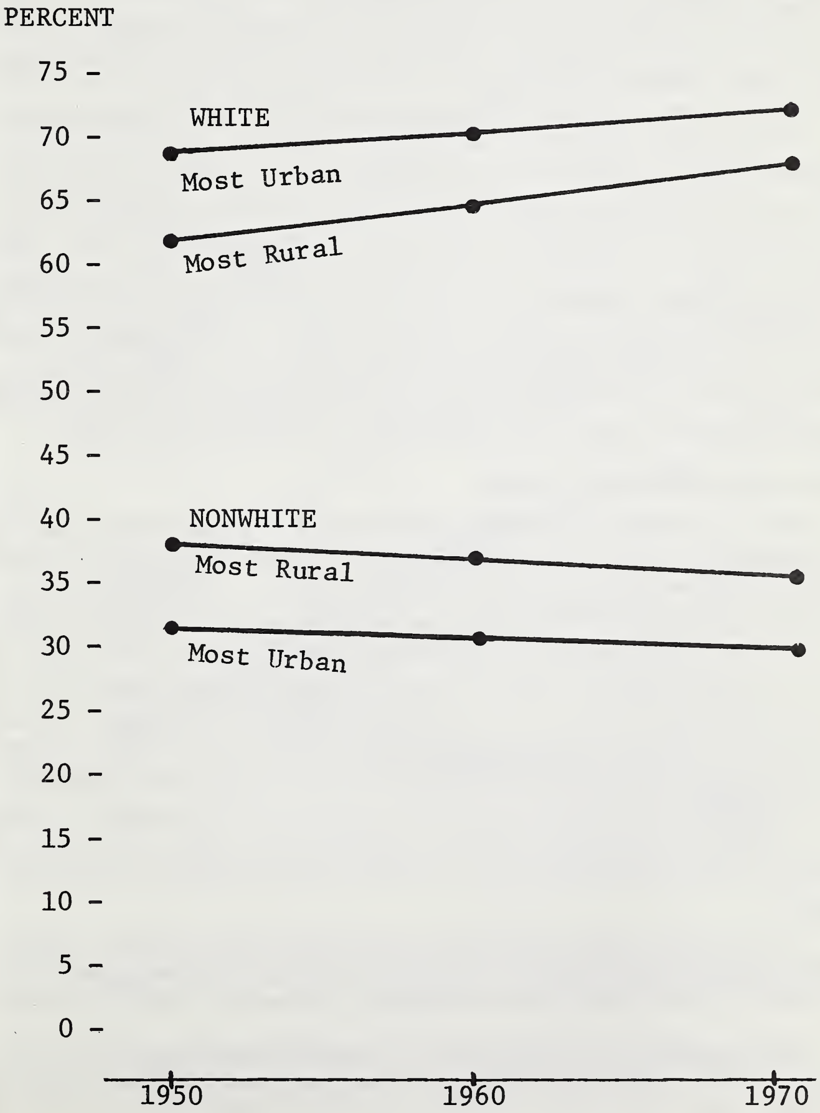
*There were 6 Most Urban Parishes in 1950 and 9 in 1960 and 1970.

**There were 42 Most Rural Parishes in 1950, 32 in 1960, and 27 in 1970.

The proportion of whites and nonwhites in the most urban and most rural parishes remained fairly constant over time (Figure 6; and Table 4 in the Appendix). In the most rural parishes the percentage of the population composed of whites increased from 63.7 percent in 1950 to 64.3 percent in

FIGURE 6

Percent White and Nonwhite in Most Rural and Most Urban Parishes, 1950, 1960, and 1970



1960 to 65.8 percent in 1970. For these same points in time the nonwhite population of the most rural parishes decreased from 36.3 percent to 35.7 percent to 34.2 percent. [At least part of this decline in the rural nonwhite percentages can be accounted for by the increased migration of this subpopulation to the urban areas.] In the most urban parishes also, the proportion of the population that was white increased slightly. The percentages are 69.1 percent, 69.3 percent, and 69.5 percent for 1950, 1960, and 1970, respectively. The proportion of the population that was nonwhite decreased slightly from 30.9 percent to 30.7 percent to 30.5 percent for the three points in time. It is evident that the white and nonwhite proportions of the population were fairly similar in the most rural and the most urban parishes of the state. The nonwhite proportion of the population consistently fell in the 30-35 percent range for the most rural *and* the most urban parishes.

A final observation is in order on the percent of all urban and rural persons in the most urban and most rural parishes. In 1950, 71.0 percent of all people classified as urban lived in the most urban parishes; this had changed to 72.0 percent by 1960 and to 71.6 percent by 1970. Thus approximately 7 out of every 10 persons classified as urban in Louisiana lived in parishes which were at least 65 percent urban. For the rural population, 62.0 percent of all people classified as rural in 1950 lived in the most rural parishes, while this had changed to 42.7 percent by 1960 and to 33.9 percent by 1970. Whereas 6 out of every 10 persons classified as rural in 1950 lived in a most rural parish, only 3 of 10 did so in 1970.

School-Age Population Trends

Again in keeping with Smith and Bertrand, we have operationalized "school-age" as being between the ages of 7 and 17, "the ages at which children and youths are most likely to be in school."[11] In 1950 there were 524,545 school-age youths in Louisiana, and this number had increased to 731,455 by 1960 and to 882,475 by 1970, an actual increase of 357,930, or 68.2 percent, between 1950 and 1970 and a sharp divergence from the 35.8 percent growth for the state as a whole (Figure 7; and Table 5 in the Appendix). Whites constituted 62.7 percent of school-age youth in 1950, 63.7 percent in 1960, and 64.9 percent in 1970 with nonwhites making up 37.3 percent, 36.3 percent, and 35.1 percent at each respective time period. Whites increased at a faster rate than blacks, with a 74.3 percent increase (244,276 persons) versus a 58.0 percent increase (113,654 persons).

The percent of school-age children in the most urban parishes continuously increased as a percent of total state school-age population, while the reverse was true for the most rural parishes. Between 1950 and 1970 the

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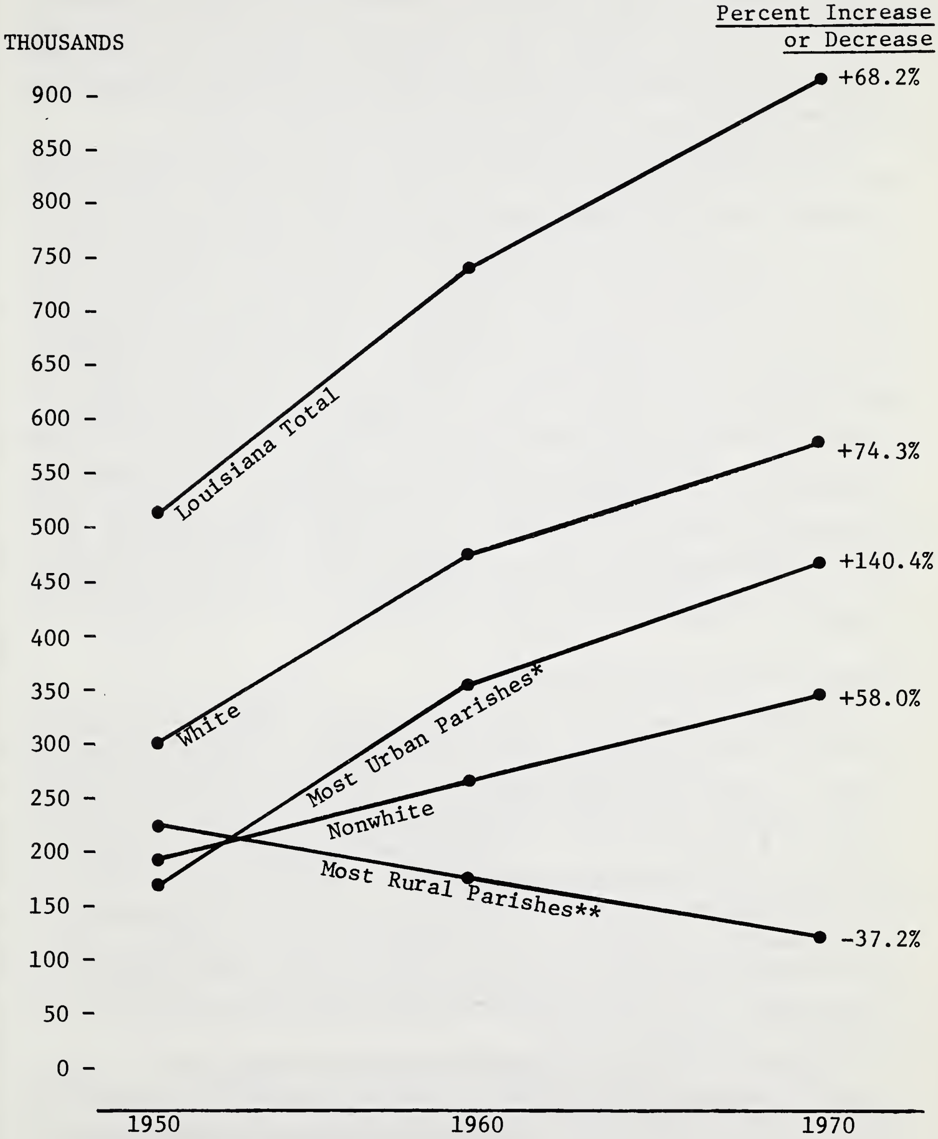
[11] Smith and Bertrand, p. 11. We realize that, given current pedagogical practice, this is a very conservative estimate. It is necessary, however, to make our analysis comparable to that of Smith and Bertrand.

FIGURE 7

Changes in the Number of Persons 7-17 Years Old in Louisiana, 1950–1970, by Race and Most Urban and Most Rural Parishes



*There were 6 Most Urban Parishes in 1950 and 9 in 1960 and 1970.

**There were 42 Most Rural Parishes in 1950, 32 in 1960, and 27 in 1970.

most urban parishes had school-age population growth of 140.4 percent (265,185 persons), whereas the most rural parishes decreased by 37.2 percent (78,606 persons). For each census year, the most urban school-age population as a percent of total state school-age population increased, going from 36.0 percent in 1950 to 47.9 percent in 1960 to 51.1 percent in 1970, the point at which over half of all school-age children in the state lived in only nine parishes. The school-age population of most rural parishes declined from 40.3 percent of the total school-age population in 1950 to 21.6 percent in 1960 to only 15.0 percent in 1970.

It must be kept in mind that these are trends of most urban and most rural parishes and that the number of parishes varies by year. What we are reporting is the most urban or most rural parishes at a given point in time. We are not comparing the same parishes at each point in time by either name or number; what is held constant is the criteria for inclusion in the analysis of being *either* at least 65 percent urban or rural at each point in time. Since we have already demonstrated a change in the general population composition of these parishes (Figures 5 and 7; and Tables 1 and 5 in the Appendix) we would expect an increase in the actual number of school-age children in the most urban parishes and a decrease in the most rural parishes. The significant finding here is that by 1970 the school-age children in the most rural parishes accounted for only 15 percent of all school-age children in the state — a very sharp decline from the 40.3 percent who had resided in the most rural parishes in 1950. And, as noted, over half of all school-age children in the state lived in just nine urban parishes by 1970.

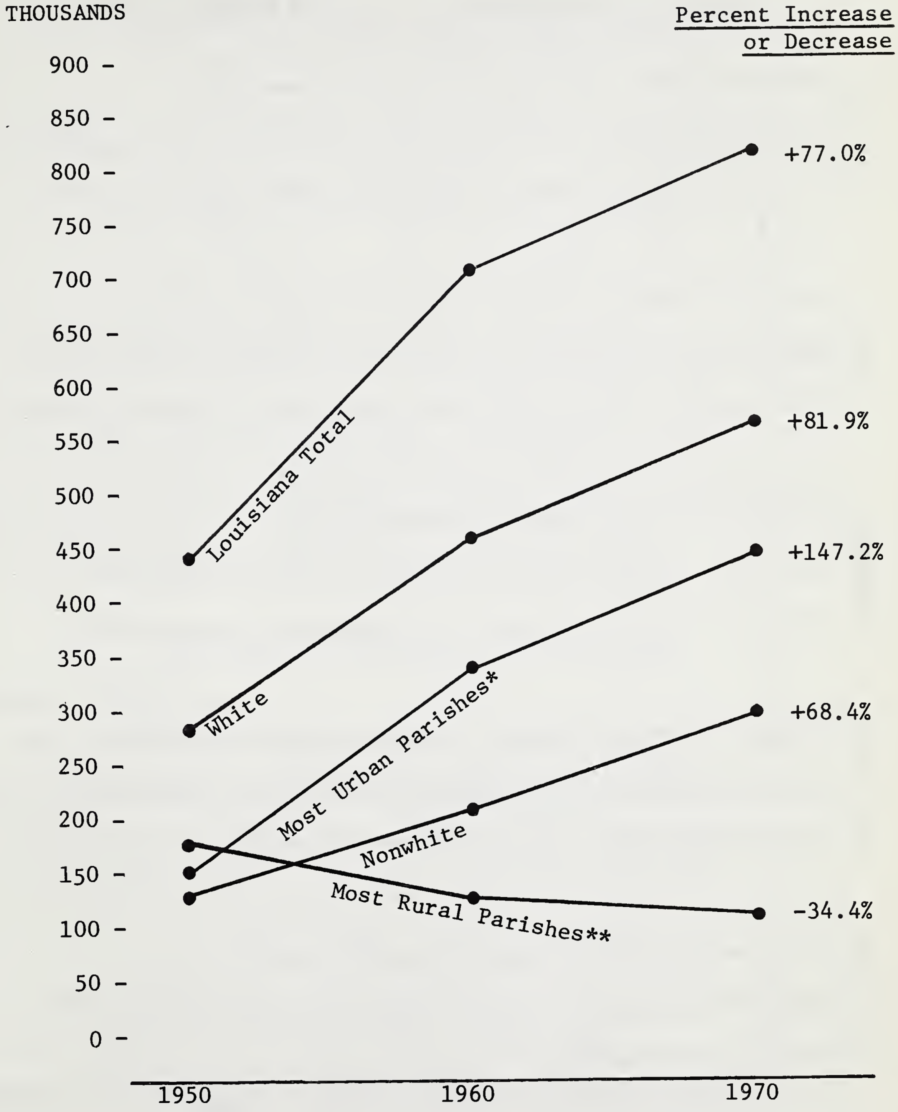
Trends in School Attendance

Paralleling the increase in school-age population, there was also a large increase between 1950 and 1970 in the number of children enrolled in school — an actual increase of 363,324, or 77.0 percent (Figure 8; Table 6 in the Appendix). The white population enrollment increased by 246,090, a gain of 81.9 percent; but nonwhite enrollment gained less markedly, growing by 68.4 percent (an actual gain of 117,234 children). When we examine white and nonwhite enrollment as proportions of total enrollment, we find that the percentages are remarkably stable between 1950 and 1970. White enrollment was 64 percent of total enrollment in 1950 and 1960 and 65 percent in 1970, while nonwhite enrollment was 36 percent in 1950 and 1960 and 35 percent in 1970.

In addition to the proportionate white-nonwhite enrollments, an equally interesting finding is the percentages of both groups that are enrolled as a percent of either total white or nonwhite school-age population (Figure 9; and Table 6 in the Appendix). In 1950 the percent of whites enrolled was 91.4, and this percentage had increased to 94.9 by 1960 and to 95.4 by 1970. For nonwhites, only 87.6 percent of those 7-17 years of age were

FIGURE 8

Population 7-17 Years Old Enrolled in School in Louisiana, 1950–1970, by Race and Most Urban and Most Rural Parishes

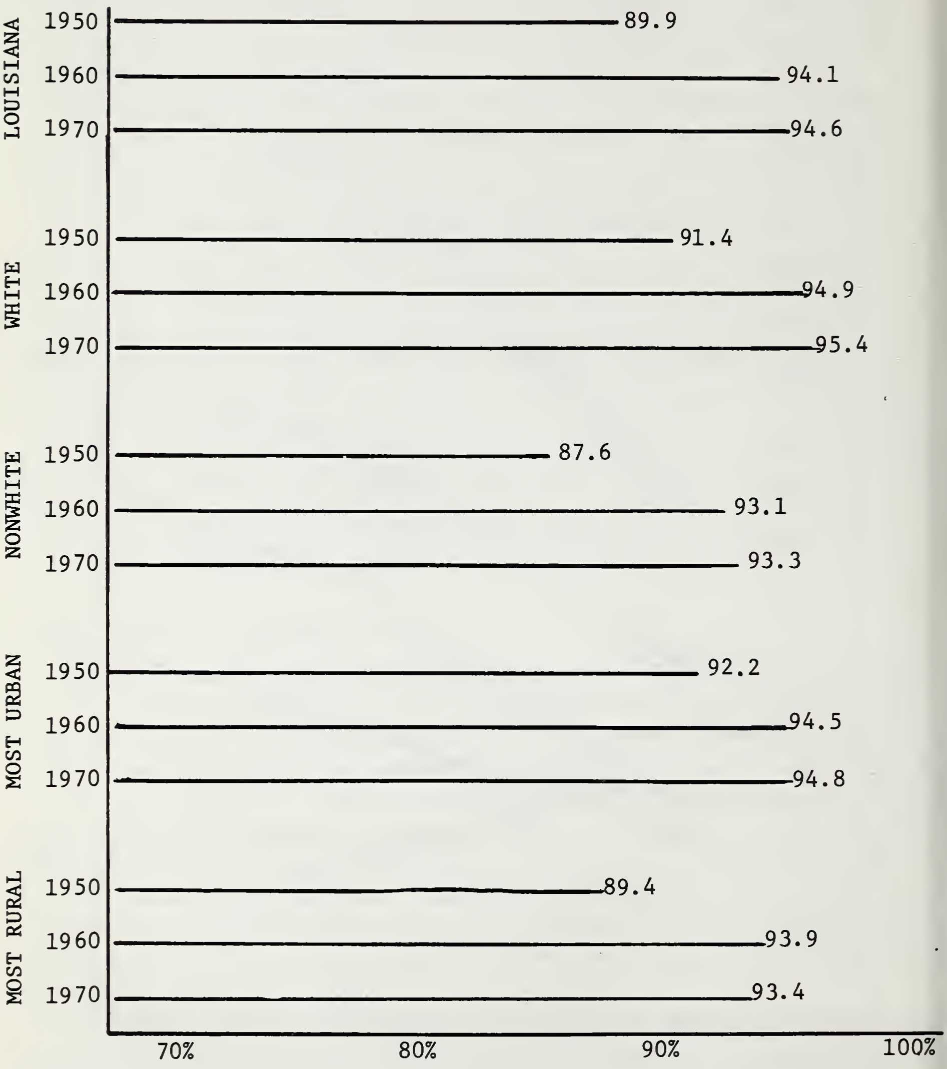


*There were 6 Most Urban Parishes in 1950 and 9 in 1960 and 1970.

**There were 42 Most Rural Parishes in 1950, 32 in 1960, and 27 in 1970.

FIGURE 9

Percent of Total Population 7-17 Years Old Enrolled in School



enrolled in 1950, but this percentage had increased to 93.1 by 1960 and again, but very minimally, to 93.3 by 1970.[12] Apparently by 1960 the white-nonwhite disparity, at least when assessed by percent of the student-aged population enrolled, had largely diminished, although it had not been completely eliminated.

When we compare the most urban and most rural categories of parishes, we also see some interesting trends. The most urban parishes grew progressively larger in both actual numbers of school-age children and as a percentage of school enrollment, while the reverse was true for the most rural parishes. The most urban parishes gained by 256,397 persons, or 147.2 percent. But the most rural parishes decreased by 64,882, or 34.4 percent. Neither urban nor rural parishes were too different in terms of percent enrolled, although the most urban parishes were consistently higher on this score. What was especially interesting was the comparison of most urban and most rural parishes as a percent of total state enrollment. In 1950 the most urban parishes accounted for 36.9 percent, but this had increased to 48.1 percent by 1960 and to 51.6 percent by 1970. But for the most rural parishes the percentages went from a high of 40.0 in 1950 to 21.5 in 1960, with a further decrease to 14.8 by 1970. Whereas 4 of every 10 enrolled school-age children lived in the most rural parishes in 1950, only about one and one-half of every 10 did so in 1970. For urban parishes the growth proceeded to a point in 1970 where just over half of all enrolled school-age children lived in the nine most urban parishes.

Teachers in Louisiana Public Schools

Teacher Distribution

One would expect that the change in number of teachers would be approximately equal to the change in school-age population enrollment. But in point of fact, the growth in the number of teachers has exceeded that of school-age population. Between 1950 and 1970, school-age population enrollment increased by 77.0 percent, whereas the total number of public school teachers increased from 17,400 to 42,235 (in 1973-74), an increase of 24,835, or 142.7 percent (Figure 10; Table 7 in Appendix). Just as this was true in the aggregate data, we find a similar trend for both whites and nonwhites. Whereas the white enrollment increased by 81.9 percent and nonwhite by 68.4 percent, the white teachers increased from 11,872 in 1950-51 to 27,975 in 1973-74, an increase of 135.6 percent. Nonwhite teachers increased from 5,528 in 1950-51 to 14,260 in 1973-74, an increase of 158.0 percent. Thus when we examine the growth rates for

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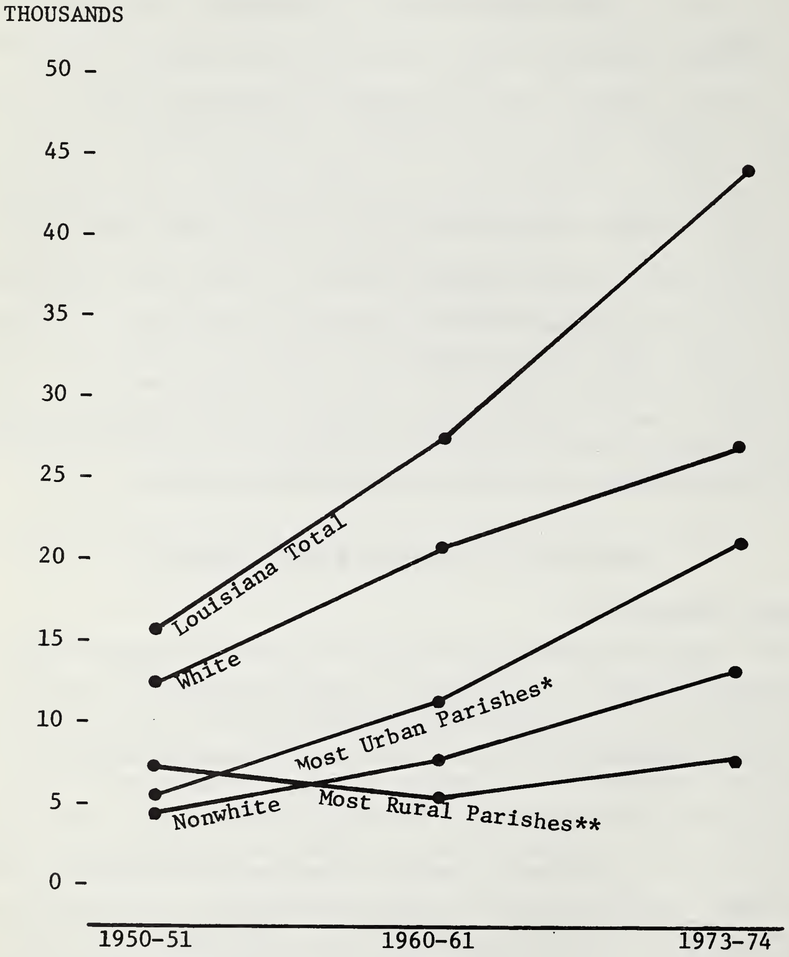
[12] In all cases for enrollments, the deviation from 100% is no doubt accounted for, at least in part, by such things as being in special education programs, having already graduated, having dropped out of school, etc.

FIGURE 10

Total Number of Public School Teachers (and Principals) in Louisiana by Race and Most Urban and Most Rural Parishes, 1950–51, 1960–61, and 1973–74 Sessions



*There were 6 Most Urban Parishes in 1950-51 and 9 in 1960-61 and 1973-74.

**There were 42 Most Rural Parishes in 1950-51, 32 in 1960-61, and 27 in 1973-74.

teachers in Louisiana public schools versus school enrollment, it is apparent that teachers have increased at a faster pace than the number of students.

The change already noted in the general population and school-age population was found in most urban and most rural parishes and is also found in the distribution of teachers in Louisiana. In 1950-51, 43.9 percent of all public school teachers in the state were in the 42 most rural parishes, whereas only 31.9 percent were in the most urban parishes. By 1960-61 this pattern had reversed so that 43.2 percent were in the most urban parishes but only 24.4 percent in the most rural parishes. And, in 1973-74, most urban parishes had 47.4 percent of all the state's public school teachers versus 16.9 percent found in the most rural parishes.

Teacher Training

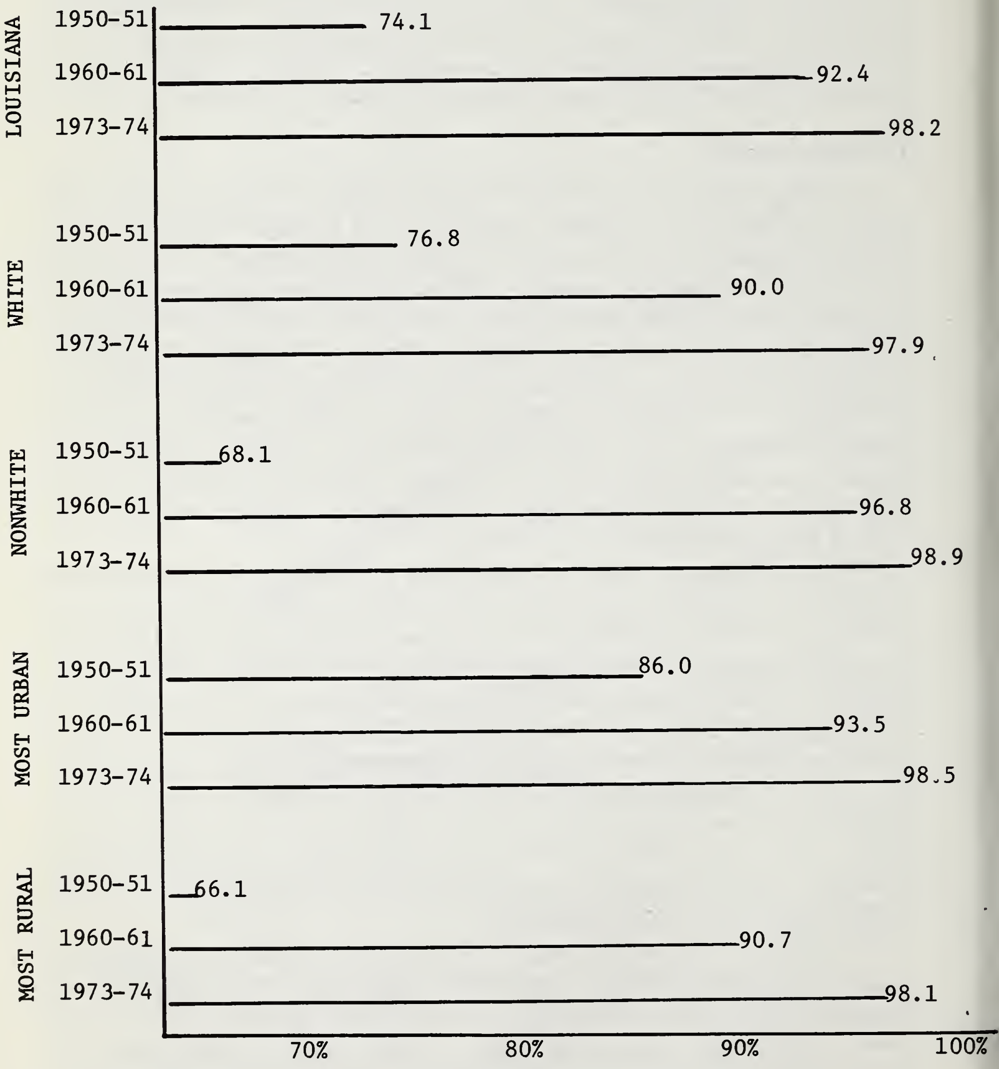
It is also of interest to compare the percentages of teachers in the most urban and most rural parishes who have (a) a college degree and (b) a graduate degree. In the first case, 74.1 percent of all public school teachers in Louisiana had a college degree in 1950-51. Eighty-six percent of those in the most urban parishes had a degree, as compared with only 66.1 percent of the teachers in the most rural parishes (Figure 11; Table 7 in Appendix). This differential had changed markedly by 1960-61, when 92.4 percent of all teachers, 93.5 percent of those in the most urban parishes, and 90.7 percent of those in the most rural parishes had a degree. Almost total equality was achieved by 1973-74, when 98.2 percent of all teachers had a degree, with 98.5 percent in most urban and 98.1 percent in most rural having this qualification.

When we examine the percentages of teachers in urban and rural parishes who have a graduate degree, the findings are somewhat different. From 1950-51 to 1960-61 to 1973-74, the proportion of teachers in Louisiana who had a graduate degree (calculated on the basis of all public school teachers, including those without even an undergraduate degree) increased steadily from 9.3 percent to 21.8 percent to 32.9 percent. Teachers in most urban parishes were consistently (if only slightly) above these percentages — 15.6, 24.5, and 34.2 in 1950-51, 1960-61, and 1973-74, respectively. Rural teachers were consistently (if only slightly) below the state percentages — 6.0, 19.4, and 31.4 for the same time periods. It seems apparent, however, that the historical disparity had largely abated by 1973-74 with only a small rural-urban difference.

Comparisons may also be made between the distributions and training of white and nonwhite teachers. Between 1950-51 and 1973-74 the white/nonwhite proportions of all public school teachers were very similar, with white percentages going from 68.2 to 65.0 to 66.2, while nonwhite percentages were 31.8, 35.0, and 33.8, respectively. The white/nonwhite distributions were also similar in the most urban and the most rural parishes. The similarities fade, however, when we examine the training of

FIGURE 11

Percent of Public School Teachers With Degrees in Louisiana by Race and Most Urban and Most Rural Parishes, 1950–51, 1960–61, and 1973–74 Sessions



the two groups — with a surprising advantage going to nonwhites. Between 1950-51 and 1973-74, the percentage of whites with degrees increased steadily from 76.8 to 90.0 to 97.9; for nonwhites the increase was more dramatic, going from 68.1 to 96.8 to 98.9. In short, from 1950-51 to 1960-61, nonwhites increased their members with college degrees by nearly 30 percent; the increase was so great that a larger percentage of nonwhite teachers than whites were degree holders. Although of less magnitude, nonwhites also had more college graduates as teachers in 1973-74. As may be seen in Table 7 in the Appendix, this historical difference is found in both the most urban and the most rural parishes categories, with an incredible increase in the nonwhite most rural category in which a gain of nearly 40 percent was observed between 1950-51 and 1960-61 (from 56.4 to 95.6).

Little differences are found in the relative percentages of whites and nonwhites with graduate degrees — at least by the 1973-74 school year (Figure 12; Table 7 in Appendix). Whites clearly had larger percentages with graduate degrees in 1950-51 and 1960-61 (11.9 versus 3.8 and 25.2 versus 15.4 for whites and nonwhites, respectively); but in 1973-74, the two groups were nearly equal — 33.1 percent for whites versus 32.6 percent for nonwhites. In addition, the whites and nonwhites when compared within the most urban and most rural categories were nearly equal by 1973-74. Of all white teachers in the most urban parishes category, the percentages with graduate degrees increased from 18.8 to 26.4 to 34.3 between 1950-51 and 1973-74; for nonwhites the percentages started out at a low of 9.2, increased to 21.0 percent, and most recently rose to 34.0 percent. Over the same time period in the most rural parishes category, the percentages of white teachers with graduate degrees went from 8.4 to 24.9 to 31.1 percent, while nonwhites increased from 0.9 to 9.8 to 31.9 percent. Again, by 1973-74, the historical disparity between whites and nonwhites had largely diminished.

Teacher Experience

Another teacher-related variable is their years of experience. The discussion here concentrates on two extremes — 0-4 years experience, which we may assume to be fairly new, inexperienced teachers, (Figure 13; Table 8 in Appendix) and 15 or more years experience, which we may assume to be older, more experienced teachers, (Figure 14; Table 8 in Appendix).

In 1950-51, for the state as a whole, there was a disproportionate number of public school teachers in the more experienced category (44.7 percent). By 1960-61 the percentages had changed slightly but the more experienced category still had a large percentage of the state's teachers (41.4 percent). But the distribution was much different in 1973-74, with the least experienced and most experienced categories being nearly equal (29.5 percent versus 31.2 percent).

FIGURE 12

Percent of Public School Teachers (and Principals) With Graduate Degrees in Louisiana by Race and Most Urban and Most Rural Parishes, 1950–51, 1960–61, and 1973–74 Sessions

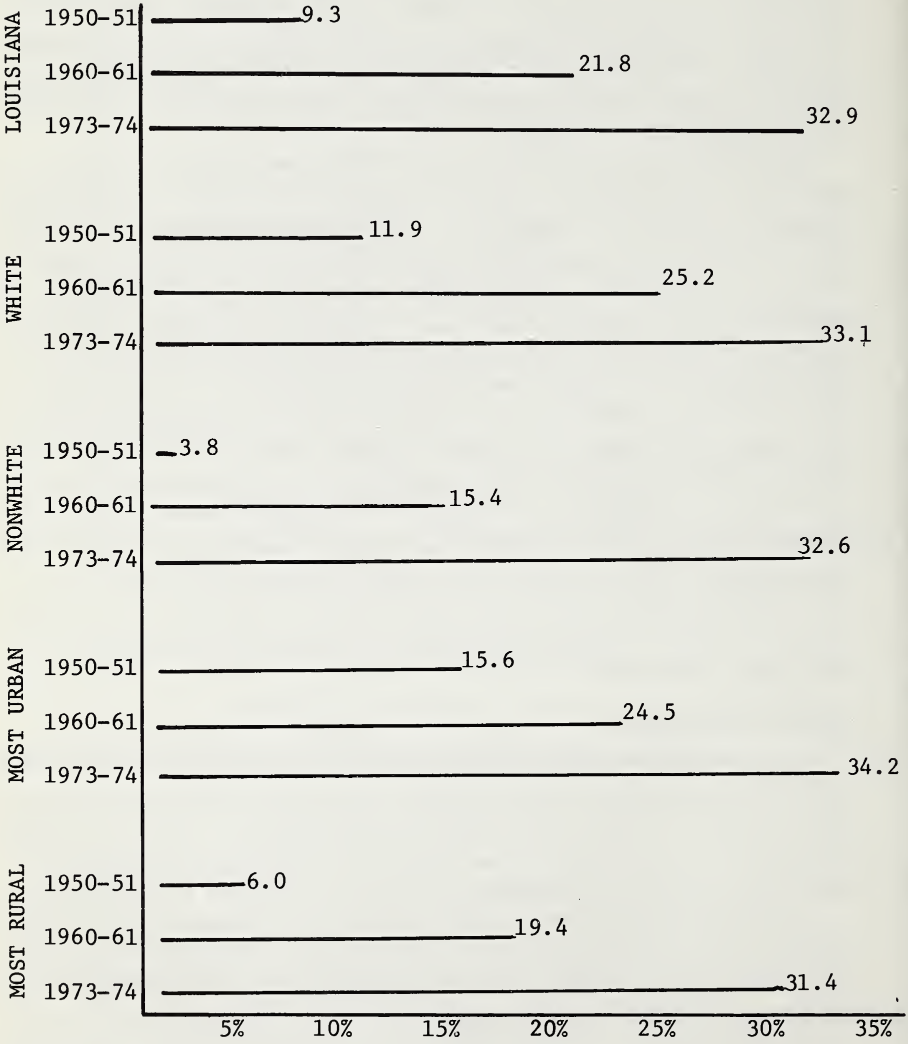


FIGURE 13

Percent of Public School Teachers (and Principals) With 0-4 Years Experience in Louisiana by Race and Most Urban and Most Rural Parishes, 1950–51, 1960–61, and 1973–74 Sessions

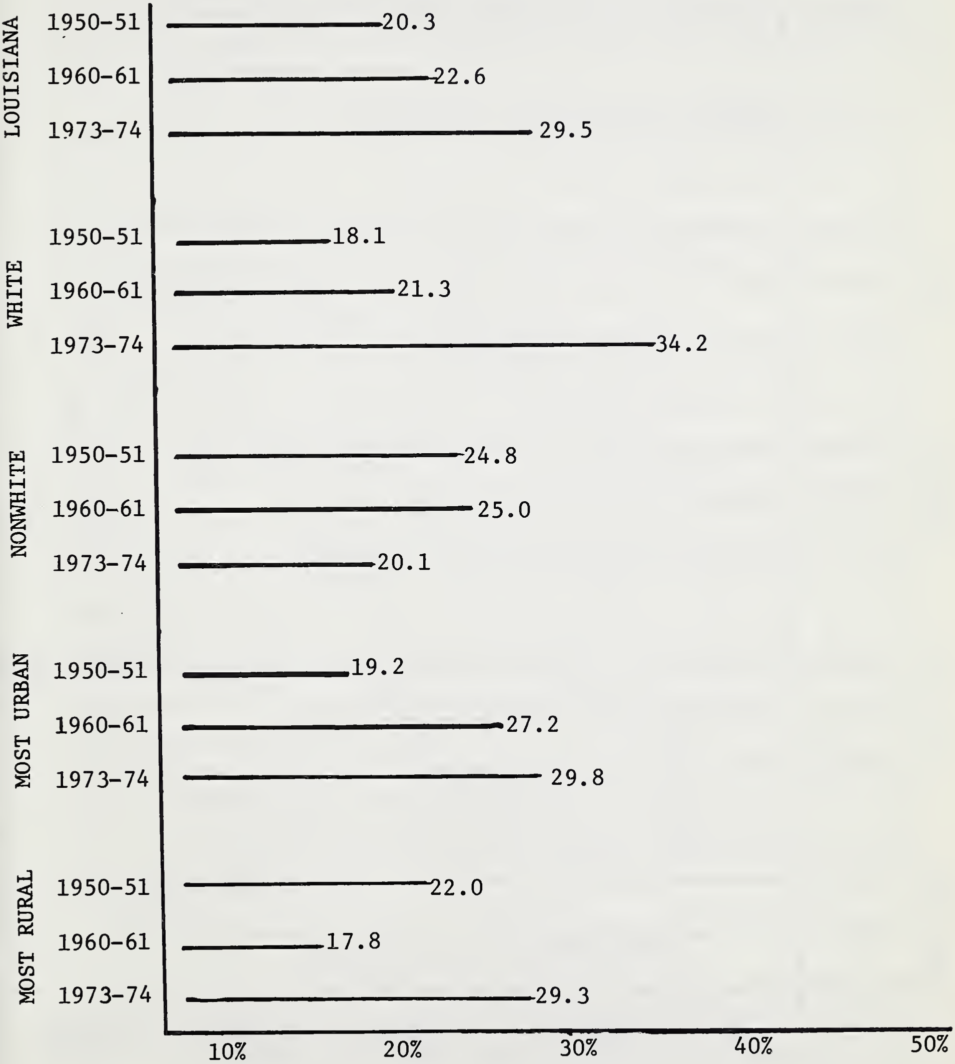
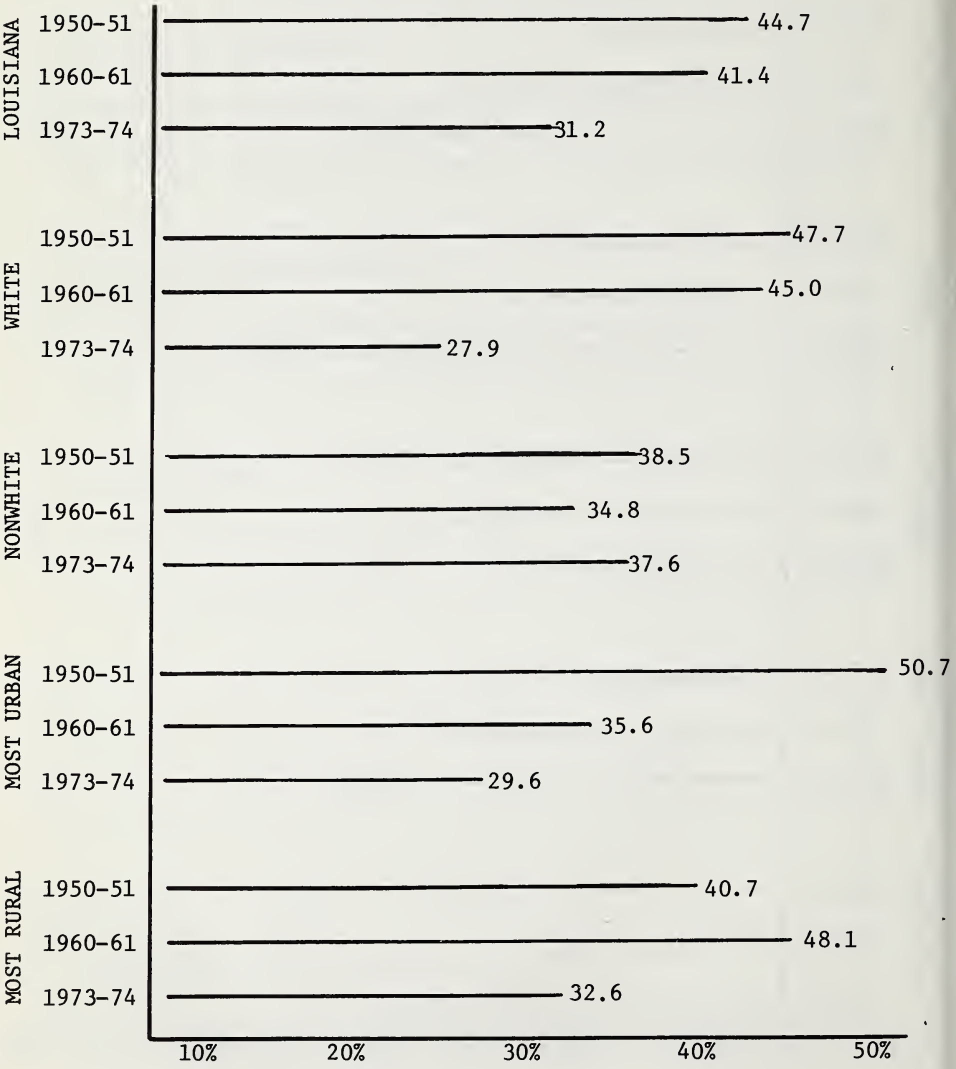


FIGURE 14

Percent of Public School Teachers (and Principals) With 15+ Years of Experience in Louisiana by Race and Most Urban and Most Rural Parishes, 1950–51, 1960–61, and 1973–74 Sessions



When we compare whites and nonwhites we find some rather sharp differences. In 1950-51 whites included more teachers in the experienced category (47.7 percent for whites versus 38.5 for nonwhites) and fewer teachers in the less experienced category (18.1 percent for whites versus 24.8 for nonwhites). This picture had changed little by 1960-61, with white percentages in most and least experienced categories being 45.0 and 21.3 versus 34.8 and 25.0 for nonwhites. However, by 1973-74 this pattern had reversed; whites had a larger percentage than nonwhites with less experience (34.2 versus 20.1) and a smaller percentage with more experience (27.9 versus 37.6).

The patterns noted in the aggregate state data were mirrored in the most urban and the most rural parishes. In 1950-51, both categories of parishes had large percentages in the most experienced column, with the urban percentage being larger than the rural one (50.7 versus 40.7). This was reversed in 1960-61, when the rural percentage was higher than the urban for most experienced (48.1 for rural versus 35.6 for urban). But in 1973-74, both the most urban and the most rural parishes were like the state as a whole with little difference between them.

Just as there were historical differences between whites and nonwhites in the total state data, so, too, were there differences between these groups in the urban and rural settings studied. In 1950-51 and 1960-61, the white and nonwhite differences in the most urban parishes were minimal; but in 1973-74, urban whites had far more persons in the least experienced category (34.7 percent for whites but only 21.1 percent for nonwhites), while the reverse was true in the most experienced category (26.3 for whites but 35.4 for nonwhites). A somewhat similar trend was found in the most rural parishes, although whites had far fewer persons in the least experienced category in 1950-51 and 1960-61 (18.8 percent and 15.0 percent versus 28.7 percent and 22.9 percent, for whites and nonwhites, respectively). At the same time, whites had larger percentages in the most experienced category (45.1 and 53.9 versus 31.4 and 37.5). Again, as in the urban case, the reverse of this was found in 1973-74, when proportionately more whites were in the least experienced category (35.4 percent for whites, 18.0 percent for nonwhites) and proportionately fewer in the most experienced category (28.5 percent for whites versus 40.0 percent for nonwhites).

Summary and Conclusions

Using the earlier work of Smith, and Smith and Bertrand as points of departure, this study has sought to analyze historical trends in education in Louisiana. In recent years rural areas have been given more and more visibility by the mass media and are no longer as taken-for-granted as they once were. With the possibility of reverse migration streams now leading (back) to rural areas, there is — and will continue to be — greater pressure on rural areas to provide certain services comparable in quality to those in urban areas. One such service, in particular, is education.

The current study has used census data from 1950, 1960, and 1970 and school data from comparable years (1950-51, 1960-61, and 1973-74) to assess trends in Louisiana education. The units of analysis have been the state, the most urban and most rural parishes — defined as 65 percent urban or rural at each point in time — and whites and nonwhites within the state and within the rural and urban parishes. Data were analyzed on the state population, school-age population — defined as those between 7 and 17 years of age — and all teachers in the public schools.

Summary Highlights

1. Continually greater proportions of the people of Louisiana are living in urban areas.

2. Of those people living in rural areas, there has been a tremendous decrease in the number and percentage classified as rural farm, but a tremendous increase in those classified as rural nonfarm.

3. The proportions of whites and nonwhites in the rural and urban populations of the state are nearly equal and have been nearly equal (i.e., 65-70 percent white, 30-35 percent nonwhite) for at least the last two decades.

4. The number of parishes that are 65 percent or more urban increased from six to nine between 1950 and 1970.

5. The number of parishes that are 65 percent or more rural decreased from 42 to 27 between 1950 and 1970.

6. The proportions of whites and nonwhites in the most urban and most rural parishes of the state are nearly equal and have been nearly equal (i.e., 64-70 percent white, 30-36 percent nonwhite) for at least the last two decades.

7. Between 1950 and 1970 the total population of Louisiana increased by 35.8 percent, but the school-age population increased by 68.2 percent.

8. Forty percent of all school-age children in Louisiana were in the most rural parishes in 1950, but only 15 percent were there in 1970.

9. In 1950, thirty-six percent of all Louisiana school-age children were in the most urban parishes, but by 1970 this had increased to 51 percent. (By 1970 over one-half of all school-age children in the state lived in the nine most urban parishes.)

10. Public school teachers increased at a faster rate than either the state population *or*, more significantly, the public school-age population.

11. Nonwhite public school teachers increased more than white public school teachers (158 percent to 135.6 percent) between 1950 and 1970.

12. About 44 percent of all public school teachers were in the most rural parishes in 1950, but 47 percent were in the most urban parishes in 1970.

13. The percentage of public school teachers with college degrees increased from 74 percent in 1950 to 98 percent in 1973-74.

14. By 1973-74, proportionately more nonwhite public school teachers had degrees than white public school teachers.

15. Rural-urban differences in the percentages of public school teachers with college degrees had essentially disappeared by 1973-74.

16. An initial rural-urban difference in the percentages of public school teachers with graduate degrees had disappeared by 1973-74.

17. Trends relating to teacher experience had a bimodal distribution in 1973-74 — many with little experience (under 5 years) and many with much experience (over 15 years).

18. There was little rural-urban difference in the percentages of much experienced teachers in the most rural and the most urban parishes by 1973-74.

19. The percentage of nonwhite public school teachers with a college degree was much lower than the percentage of white teachers with a college degree in 1950-51, but by 1973-74 a greater proportion of nonwhite public school teachers than white public school teachers had degrees.

20. There was a higher percentage of white public school teachers with much experience in 1950 and 1960, but by 1970 nonwhite public school teachers had the higher percentage in the much experienced category.

Conclusions and Implications

It is clear that the general population shifts in Louisiana have been like those in many other states, with the dominant trend being an increase in mostly urban parishes and a decrease in mostly rural ones. It is also apparent that Louisiana, too, has experienced a movement away from farming by many of those living in rural areas. And yet the future may see an increase in the rural population, albeit in nonfarming occupations.

Accompanying the rural-urban changes in the state's total population was a change in the number of school-age children. By 1970 only 15 percent of the state's school-age children resided in the 27 most rural parishes, while 51 percent resided in the 9 most urban parishes. A shift also occurred in the location of public school teachers. Whereas 44 percent of all public school teachers were in the 42 most rural parishes in 1950, by 1970, 47 percent of the teachers were in the 9 most urban parishes.

Rural-urban differences ceased to exist, however, in the quality of teachers. By 1973-74 there was little rural-urban difference in the percentage of public school teachers with college degrees, the percentage of public school teachers with graduate degrees, or the percentage of public school teachers in the much-experienced category of teachers.

The educational data presented in this paper demonstrate the trends in the white and nonwhite and rural and urban school-age population. Given their stability over time, little need be said except that it is obvious that the lower percentages of nonwhites in the schools seem largely an historical artifact; while there may be questions about the quality of the educational experience for nonwhites versus whites, there is little doubt that nonwhites are attending school in proportions nearly equal to those for whites.

Perhaps the most interesting findings of this study are those related to teachers. Two things in particular stand out. First, the data dramatically illustrate the ''catching up'' that has occurred for nonwhite teachers. Although starting out in 1950 with far fewer teachers holding either a bachelor's or graduate degree, by 1973-74 they had not only eliminated this deficit but were, in fact, ahead of their white counterparts. There is a temptation here to speculate as to why this may have happened. While the reasons are no doubt multifaceted, it seems safe to say that the past quarter century has seen a radical turning away from overt racial discrimination. Given HEW and OEO guidelines, nonwhites have had increasing opportunity for jobs in sectors of the labor market that were historically closed to them. Although teaching has historically been an avenue of mobility open to nonwhites, it seems reasonable to suggest here that the increase in nonwhite teachers *and* the incredible improvement in their attaining college degrees is partially due to a reduction in racial discrimination and a concomitant perception of greater opportunity. In short, we are speculating that an occupation open to nonwhites in 1950 was perceived as — and in fact was — even more attainable by 1973-74. The reversal of a greater proportion of whites having college degrees seems to support this line of reasoning. It is not the result, we suggest, of nonwhites simply putting more stress on education. Structurally, the opportunities must exist for certain goals to be attained. Thus aspiring to and attaining a college degree is only part of the picture — and a requisite at that. The larger picture deals with being able to find a teaching position once a degree is obtained, and it is here, in particular, that structural changes must occur. Recall that the percentage growth of nonwhite teachers was far greater than that for the nonwhite population or school-age population. Of course the ''real reasons'' (if they may be ascertained) are still subject to investigation.

The preceding discussion has dealt with one significant finding of this study — the growth of nonwhite teachers and their training. A second important finding, related to the first, deals with the white and nonwhite differentials and years of experience. (By 1973-74, the historical trend of greater proportions of nonwhites being less experienced than whites had reversed.) Just as we suggested that nonwhites may have perceived more opportunity, thus greater numbers of them attained college degrees, it seems that they may also make a more lasting commitment to teaching once in it. The persons in the 1973-74 cohort of greater than 15 years of experience have been teaching since at least 1958-59. Historically, nonwhites have not had the freedom to move *between* professions so much as to move *within* a profession. For example, instead of leaving teaching for a comparable profession (vis-a-vis a "job," which may be perceived of as less status even though potentially greater income producing), nonwhites may have been more likely to stay in an already secure position — say move from teacher to principal. Again this is speculation, but keep in mind that the late 1960's and early 1970's were a time of turbulence in education, especially in Louisiana, where school desegregation occurred full force around 1970. For whites this could have expedited leaving the profession. In any case, the data demonstrate the change in the distribution of those with varying years of experience; the reasons for this redistribution are still speculative.

The analysis reported in this paper is only part of a much larger body of work currently in progress. Hopefully, questions raised in this paper will be answered in later papers which will detail historical trends with data of one-year intervals — thus if *a* turning point occurred it may be detectable. The present paper has merely shown the decrease in children directly affected by rural education and certain parallels between the educational structures in rural and urban areas. While our emphasis here has been on what seemed the significance of white and nonwhite differentials, our larger goal remains the investigation of educational equity between rural and urban areas. And it is to that end that our future work will address itself.

APPENDIX

Table 1.–Population Trends in Louisiana, 1950–1970, by Race, Residence, and Most Urban and Most Rural Parishes

Population Group	1950	1960	1970	Increase or Decrease 1950-1970	
				Number	Percent
TOTAL	2,683,516	3,257,022	3,643,180	959,664	35.8
Residence					
Urban	1,471,696	2,060,606	2,406,150	934,454	63.5
Rural-Farm	567,455	233,138	113,757	-453,698	-80.0
Rural-Nonfarm	644,365	963,278	1,118,627	474,262	73.6
Race					
Whites	1,796,683	2,211,954	2,541,498	744,815	41.5
Urban	1,022,931	1,415,619	1,666,021	643,090	62.9
Rural-Farm	332,608	141,739	85,190	-247,418	-74.4
Rural-Nonfarm	441,144	654,516	794,742	353,598	80.2
Nonwhites	886,833	1,045,068	1,099,808	212,975	24.0
Urban	448,765	644,907	745,446	296,681	66.1
Rural-Farm	234,847	91,399	28,567	-206,271	-87.8
Rural-Nonfarm	203,221	308,762	323,885	120,664	59.4
Most Urban Parishes	1,173,449	1,678,814	1,928,480	755,031	64.3
Urban	1,045,421	1,482,560	1,723,795	678,374	64.9
Rural-Farm	35,186	16,100	7,856	-27,330	-77.7
Rural-Nonfarm	92,842	180,154	196,829	103,987	112.0
Most Rural Parishes	907,427	636,854	522,721	-384,706	-42.4
Urban	155,778	125,912	105,034	-50,755	-32.6
Rural-Farm	376,232	104,546	44,054	-332,178	-88.3
Rural-Nonfarm	375,417	406,396	373,633	-1,784	-0.5

Table 2.–A Listing of the Most Rural Parishes in 1950, 1960, and 1970

1950		1960		1970	
Most Rural Parishes	Percent Rural	Most Rural Parishes	Percent Rural	Most Rural Parishes	Percent Rural
Assumption	100.0	Assumption	100.0	Assumption	100.0
Bienville	100.0	Caldwell	100.0	Caldwell	100.0
Caldwell	100.0	Cameron	100.0	Cameron	100.0
Cameron	100.0	Catahoula	100.0	Grant	100.0
Catahoula	100.0	East Feliciana	100.0	LaSalle	100.0
Grant	100.0	Grant	100.0	Red River	100.0
LaSalle	100.0	LaSalle	100.0	St. Helena	100.0
Livingston	100.0	Red River	100.0	Tensas	100.0
Plaquemines	100.0	St. Helena	100.0	West Carroll	100.0
Red River	100.0	Tensas	100.0	West Feliciana	100.0
Sabine	100.0	West Carroll	100.0	Sabine	83.3
St. Helena	100.0	West Feliciana	100.0	Pointe Coupee	82.1
St. James	100.0	Bienville	84.8	Bienville	81.5
Tensas	100.0	Union	84.5	Livingston	81.5
Union	100.0	Franklin	83.0	Union	81.5
West Carroll	100.0	Sabine	83.0	Franklin	77.7
West Feliciana	100.0	Pointe Coupee	82.4	Catahoula	76.5
Richland	88.2	St. James	82.2	Avoyelles	73.7
Franklin	87.6	St. Charles	77.9	East Feliciana	73.4
Pointe Coupee	87.1	Livingston	77.9	St. Charles	72.8
St. Martin	82.5	DeSoto	75.9	DeSoto	71.7
DeSoto	81.8	Jackson	75.7	Plaquemines	71.7
Ascension	81.5	Avoyelles	74.9	Richland	68.5
Jackson	79.9	Vernon	74.4	Jackson	68.2
Evangeline	79.0	Iberville	74.3	Ascension	68.0
Iberville	78.5	Richland	72.4	St. James	67.2
Avoyelles	78.2	Evangeline	67.0	Iberville	66.7
St. Bernard	76.2	Allen	66.7		
Vernon	75.4	Ascension	66.6		
Lafourche	75.0	St. Martin	66.4		
St. Charles	74.8	St. Tammany	66.1		
East Carroll	74.7	Plaquemines	65.5		
St. Landry	74.7				
Natchitoches	74.0				
West Baton Rouge	73.6				
Concordia	73.3				
Tangipahoa	72.0				
Allen	70.3				
St. John	70.0				
Claiborne	68.9				
St. Tammany	68.2				
Beauregard	67.4				
N = 42		N = 32		N = 27	

Table 3.—A Listing of the Most Urban Parishes in 1950, 1960, and 1970

1950 Most Urban Parishes	1950 Percent Urban	1960 Most Urban Parishes	1960 Percent Urban	1970 Most Urban Parishes	1970 Percen Urban
Orleans	100.0	Orleans	100.0	Orleans	99.7
Jefferson	88.8	Jefferson	94.1	Jefferson	95.8
East Baton Rouge	85.8	East Baton Rouge	85.1	St. Bernard	91.3
Caddo	75.6	Caddo	80.8	East Baton Rouge	86.9
Calcasieu	72.2	Ouachita	79.2	Caddo	85.5
Ouachita	65.4	Calcasieu	73.9	Ouachita	78.5
		Iberia	67.0	Calcasieu	74.8
N = 6		Bossier	66.0	Lafayette	71.6
		St. Bernard	66.0	St. Mary	65.2
		N = 9		N = 9	

Table 4.—Population Trends in Louisiana, 1950–1970, by Race for Most Urban and Most Rural Parishes

	1950	1960	1970
Most Rural Parishes	907,427	636,854	523,053
White	578,071	409,682	343,991
% White	63.7%	64.3%	65.8%
Nonwhite	329,356	227,172	179,062
% Nonwhite	36.3%	35.7%	34.2%
Most Urban Parishes	1,173,439	1,680,814	1,928,845
White	810,499	1,164,421	1,340,558
% White	69.1%	69.3%	69.5%
Nonwhite	362,940	516,393	588,287
% Nonwhite	30.9%	30.7%	30.5%

Table 5.—Changes in the Number of Persons 7-17 Years Old in Louisiana, 1950–1970, by Race and Most Urban and Most Rural Parishes

Population Group 7-17 Years Old	1950	1960	1970	Increase or Decrease 1950-1970	
				Number	Percent
TOTAL POPULATION	524,545	731,455	882,475	357,930	68.2
Whites	328,685	465,982	572,961	244,276	74.3
Nonwhites	195,860	263,926	309,514	113,654	58.0
Most Urban Parishes	188,895	350,619	454,080	265,185	140.4
Most Rural Parishes	211,265	157,639	132,659	-78,606	-37.2

Table 6.–Changes in Number of Persons 7-17 Years Old Enrolled in School in Louisiana, 1950–1970, by Race and Most Urban and Most Rural Parishes

Population Group 7-17 Years of Age Enrolled in School	1950	1960	1970	Increase or Decrease 1950-1970	
				Number	Percent
Total Population Enrolled	471,810	688,336	835,134	363,324	77.0
Percent Enrolled	89.9	94.1	94.6		
White Pop. Enrolled	300,315	442,477	546,405	246,090	81.9
Percent Enrolled	91.4	94.9	95.4		
Nonwhite Pop. Enrolled	171,495	245,859	288,729	117,234	68.4
Percent Enrolled	87.6	93.1	93.3		
Number Enrolled, Most Urban Parishes	174,165	331,325	430,562	256,397	147.2
Percent Enrolled	92.2	94.5	94.8		
Number Enrolled, Most Rural Parishes	188,825	147,947	123,943	-64,882	-34.4
Percent Enrolled	89.4	93.9	93.4		

Table 7.—Trend in Professional Training of Public School Teachers (and Principals) in Louisiana by Race and Most Urban and Most Rural Parishes, 1950–51, 1960–61, and 1973–74 Sessions

Residence and Race Group	1950–51 Session					1960–61 Session					1973–74 Session				
	Total # of Teachers	Teachers with Degrees				Total # of Teachers	Teachers with Degrees				Total # of Teachers	Teachers with Degrees			
		Bachelor's	Master's	Ph.D./ Ed.D	Total		Bachelor's	Master's	Ph.D./ Ed.D	Total		Bachelor's	Master's	Ph.D./ Ed.D.	Total
Louisiana	17,400	11,263	1,621	0	12,884	27,726	19,564	6,030	22	25,616	42,235	27,589	13,815	83	41,487
% w/Degrees	74.1					92.4					98.2				
White	11,872	7,708	1,411	0	9,119	18,036	11,676	4,539	21	16,236	27,975	18,139	9,173	74	27,386
% w/Degrees	76.8					90.0					97.9				
Nonwhite	5,528	3,555	210	0	3,765	9,690	7,888	1,491	1	9,380	14,260	9,450	4,642	9	14,101
% w/Degrees	68.1					96.8					98.9				
Most Urban Parishes	5,543	3,902	866	0	4,768	11,975	8,266	2,918	13	11,197	20,035	12,888	6,802	49	19,739
% w/Degrees	86.0					93.5					98.5				
White	3,723	2,469	699	0	3,168	7,664	4,949	2,012	12	6,973	12,754	8,159	4,334	41	12,534
% w/Degrees	85.1					91.0					98.3				
Nonwhite	1,820	1,433	167	0	1,600	4,311	3,317	906	1	4,224	7,281	4,729	2,468	8	7,205
% w/Degrees	87.9					98.0					99.0				
Most Rural Parishes	7,631	4,589	455	0	5,044	6,758	4,811	1,313	5	6,129	7,120	4,748	2,220	13	6,981
% w/Degrees	66.1					90.7					98.1				
White	5,176	3,226	433	0	3,659	4,343	2,739	1,076	5	3,820	4,610	3,058	1,419	13	4,490
% w/Degrees	70.7					88.0					97.4				
Nonwhite	2,455	1,363	22	0	1,385	2,415	2,072	237	0	2,309	2,510	1,690	801	0	2,491
% w/Degrees	56.4					95.6					99.2				

Table 8.–Trend in Professional Experience of Public School Teachers (and Principals) in Louisiana by Race and Most Urban and Most Rural Parishes, 1950–51, 1960–61, and 1973–74 Sessions

	1950–1951 Session[a]				1960–61 Session[b]				1973–74 Session[c]			
Residence and Group	% of Teachers with 0–4 Yrs. Experience	% of Teachers with 5–9 Yrs. Experience	% of Teachers with 10–14 Years Experience	% of Teachers with 15 or More Yrs. Experience	% of Teachers with 0–4 Yrs. Experience	% of Teachers with 5–9 Yrs. Experience	% of Teachers with 10–14 Years Experience	% of Teachers with 15 or More Yrs. Experience	% of Teachers with 0–4 Yrs. Experience	% of Teachers with 5–9 Yrs. Experience	% of Teachers with 10–14 Years Experience	% of Teachers with 15 or More Yrs. Experience
Louisiana	20.3	18.9	16.1	44.7	22.6	20.8	15.1	41.4	29.5	22.9	16.5	31.2
White	18.1	17.3	16.9	47.7	21.3	18.9	14.8	45.0	34.2	23.2	14.7	27.9
Nonwhite	24.8	22.3	14.5	38.5	25.0	24.4	15.9	34.8	20.1	22.2	20.2	37.6
Most Urban Parishes	19.2	15.7	14.5	50.7	27.2	23.1	14.2	35.6	29.8	23.3	17.4	29.6
White	17.8	14.9	14.4	52.8	27.6	21.0	13.8	37.6	34.7	23.9	15.0	26.3
Nonwhite	21.9	17.3	14.6	46.3	26.3	26.8	14.8	32.1	21.1	22.1	21.4	35.4
Most Rural Parishes	22.0	20.4	16.9	40.7	17.8	18.0	16.1	48.1	29.3	22.4	15.8	32.6
White	18.8	18.0	18.1	45.1	15.0	15.5	15.5	53.9	35.4	22.2	14.0	28.5
Nonwhite	28.7	25.5	14.4	31.4	22.9	22.4	17.3	37.5	18.0	22.9	19.0	40.0

[a,b,c] Reading across for each year, the rows sum to 100 percent.

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INFANT MORTALITY IN LOUISIANA

Levels, Trends, and Differentials

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INFANT MORTALITY IN LOUISIANA

Levels, Trends and Differentials

LISANDRO PEREZ AND MAISY L. CHENG*

INTRODUCTION

The study of infant mortality has long occupied a prominent place in the work of population analysts. This concern with understanding the incidence of death during the first year of life is not unwarranted. Mortality in general is one of the three population processes that form the basis of population growth (the others, of course, are fertility and migration). Because of the relatively high risk of dying before the first birthday, infant deaths account for a substantial proportion of all deaths in any population. To study infant mortality, therefore, is to study an integral component of the total mortality conditions of a population.

The significance of understanding the incidence of infant deaths, however, goes far beyond its importance for the study of general mortality. The level of infant mortality in a population is usually greatly affected by such factors as nutrition, sanitation, and health and medicine. Variations through time in the quality of those factors are reflected in the trends in infant mortality. Because of this susceptibility to the levels of living, the infant mortality rate is one of the most widely-used indexes of the general well-being of a population. It tells us a great deal about the degree of success a given society has achieved in improving the health and welfare of its people (Smith and Zopf, 1976:450).

Objectives

This study was addressed to the incidence of infant mortality in the state of Louisiana. Three major aspects were analyzed: (1) the current (1971-1973) level of infant mortality in the state in comparison with neighboring states and with the nation as a whole; (2) the direction of changes, if any, that have occurred in infant mortality in the past two decades; and (3) the differences between selected sub-populations of the state in their levels of infant mortality. The study, in other words, was concerned with levels, trends, and differentials in infant mortality in Louisiana. In addition, whenever appropriate, the official causes of death were also analyzed, principally in order to ascertain their trends and differentials.

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Methodology and Sources of Data

The most widely-used and time-tested measure of infant mortality was utilized: the infant mortality rate. It can be operationally defined as follows:

$$\frac{\text{number of deaths in a given year to children under one year of age}}{\text{number of live births during the same year}} \times 1{,}000$$

Since the rate is usually computed on an annual basis, one of its deficiencies is that the figure in the denominator is not an accurate representation of the population at risk of incurring the infant deaths shown in the numerator. In other words, some of the deaths included in the numerator may have occurred to babies born in the previous year. At the same time, some of the babies in the denominator may die in the following year and are therefore not included in the numerator. In order to substantially minimize the possibility of error introduced by this deficiency, as well as to use a rate that is more stable and representative of infant mortality conditions in the state, most of the rates that appear in this bulletin were computed on the basis of three-year groupings rather than annually. The latest three-year period for which complete data were available was from 1971 to 1973; thus the number of infant deaths during these three years was divided by the number of all live births occurring in that same time span and the result multiplied by the constant of 1,000. The 1971-1973 rates thus obtained for the state as a whole and for designated sub-populations of the state are presented in appropriate tables. They are the source of the conclusions drawn about levels and differentials. However, annual rates, presented principally through graphs, constitute the principal procedure for analyzing trends.

The study of infant mortality has always depended on the data found in the various official publications that present statistics on the occurrence of births and deaths. The mandatory registration of vital events in the United States results in fairly reliable statistics which are tabulated in both state and national statistical offices. Almost all of the data used in this study were derived from the annual volumes published by the Office of Public Health Statistics of the State of Louisiana. The only exceptions are the figures on the other southern states and on the nation as a whole, which were derived from the publications of the National Center for Health Statistics. Both of those offices do a commendable job of presenting separate tabulations on infant deaths and on providing excellent information on various demographic characteristics of deceased infants and their mothers.

It is important to point out here that, fortunately, the vital statistics utilized in this study are tabulated not according to place of occurrence, but according to the place of usual residence of the mother. We are therefore not necessarily looking at all vital events taking place in Louisiana, but rather at the births and infant deaths which occurred to persons usually residing in the state. The allocation of these vital events specifically to the mother's usual parish of residence makes possible the analysis of parish and residential differentials.

LEVELS

This brief but important section deals with two basic questions: (1) What is the current level of infant mortality in Louisiana? (2) How does this level compare with those for the rest of the South and for the entire nation? The answers to those questions can be found in Table 1. In the period from 1971 to 1973, Louisiana had a rate of 21.2 infant deaths per 1,000 live births. This rate was 14.6 percent higher than the national rate of 18.5, and 1.9 percent above the rate of the South (20.8). When the southern states are examined individually, the Louisiana rate was lower than the rates of Mississippi, Alabama, North Carolina, and South Carolina, but higher than those of Georgia, Texas, Virginia, Florida, and Arkansas.

Table 1.—Infant Mortality, 1971-1973: A Comparison of Louisiana with the Southern States and with the Total U.S. Population

States	Number of Infant Deaths	Number of Live Births	Infant Mortality Rate
United States	183,744	9,951,346	18.5
The South (excluding Louisiana)	48,711	2,336,880	20.8
Mississippi	3,662	139,165	26.3
Alabama	4,269	188,035	22.7
North Carolina	6,013	270,246	22.3
South Carolina	3,392	152,064	22.3
LOUISIANA	4,411	207,767	21.2
Georgia	5,310	266,525	19.9
Texas	13,030	653,744	19.9
Virginia	4,559	229,727	19.8
Florida	6,489	334,340	19.4
Arkansas	1,987	103,134	19.3

Source: Compiled and computed from data in the U.S. National Center for Health Statistics, *Vital Statistics of the United States*: 1971, Vol. I (Table 1-49), Vol. II (Table 2-9); *Monthly Vital Statistics Report*: 1972, Vol. 23, No. 7 (Table 1), No. 8 (Table 8); 1973, Vol. 23, No. 11, Supplement 1 (Table 8), Supplement 2 (Table 1). The Louisiana figure is computed from the Office of Public Health Statistics, *Vital Statistics of Louisiana*, Louisiana Health and Human Resources Administration, 1971 (Tables VII and XXXV), 1972 (Tables III and XIX), 1973 (Tables I and XVIII).

TRENDS

Given the above discussion, the next questions that arise are: How long have these levels been in effect? Has there been any significant change in the infant mortality rate for Louisiana in the past two decades? Has the position of the state in relation to the rest of the South and the nation remained the same in the recent past?

An examination of Figure 1 reveals that the incidence of infant mortality in Louisiana has changed considerably since 1950. In that year, approximately 35 of every 1,000 infants died before reaching their first birthday. By 1973, however, that rate had been reduced to 21. The rate of that decline, however, has not been uniform throughout the 23-year span. During the decade of the 1950s and the first half of the 1960s, the decline was slow, so that only a relatively small reduction of 11.8 percent was attained during this 15-year period. In contrast, the decline after 1965 in the incidence of infant deaths was substantial. A 32.5 percent decline was experienced within a short period of eight years.

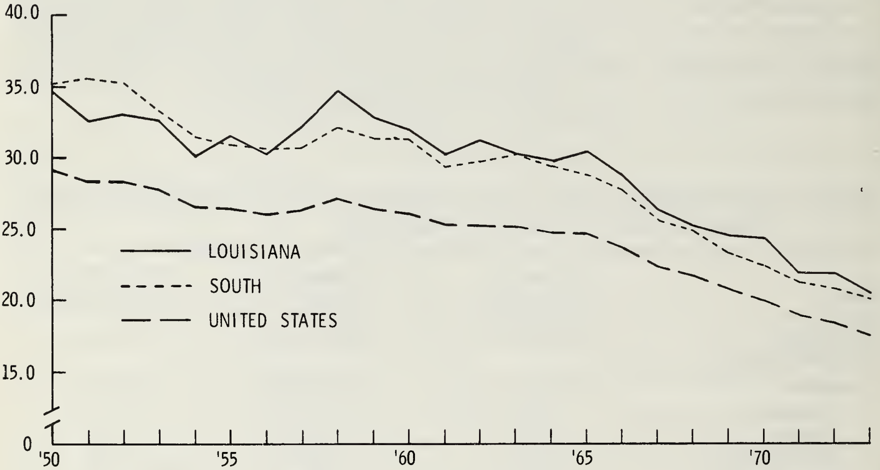

Figure 1.—Infant Mortality Rates, 1950 to 1973: A Comparison of Louisiana with the Rest of the South and with the Total U.S. Population. (Source: Prepared from data in the annual volumes of *Vital Statistics of the United States*, U.S. Department of Health, Education, and Welfare, National Center for Health Statistics, 1950 to 1973; the annual volumes of *Vital Statistics of Louisiana*, Louisiana Health and Human Resources Administration, the Office of Public Health Statistics, 1950 to 1973.)

In comparison with the national trend, also shown in Figure 1, it can be seen that since 1950 the rate for Louisiana has always been higher. However, the gap has been narrowed somewhat by the relatively greater improvement in the state's rate during the 23-year period. Louisiana experienced a 40.5 percent decrease during that time in its infant mortality rate while the nation was undergoing a slightly smaller decline of 39.4 percent. Consequently, the difference between the infant mortality rates of Louisiana and the nation has dropped from 5.4 deaths per 1,000 live births in 1950 to 2.9 in 1973.

In comparison with the rest of the South, the incidence of infant deaths in Louisiana was at a lower level throughout most of the first half of the 1950s. Since 1957, however, the rate for the state has been higher than that of the other southern states combined. It should be noted that the difference between the two populations is relatively small and no significant change in the magnitude of the gap has been observed in the past 14 years.

Undoubtedly the most noteworthy characteristic of Figure 1 is that the rapid decline since 1965 in the rate for Louisiana, mentioned earlier, is also exhibited by the South and the nation. This phenomenon has not escaped the attention of a number of demographers. The findings of a few studies done on the determinants of the national rate (Morris et al., 1975; Wright, 1972 and 1975) indicate that two major factors are associated with this relatively recent faster decline in the incidence of infant mortality in the total U.S. population. The first one is the change that occurred in the mid-sixties in the distribution of live births towards more favorable maternal ages and lower birth orders. It has long been an established fact that infant mortality varies according to age of mother and birth order. Infants born to mothers between the ages of 20 and 34 have the lowest rates of mortality. Similarly, infants of a birth order higher than third have higher rates of mortality than lower birth-order infants. In the U.S. population, between 1960 and 1970, the percent of the total live births in the six most favorable maternal-age and birth-order categories increased from 31 to 43.[1]

The second factor which various studies have identified as partly responsible for the faster rate of decline in the national infant mortality rate since 1965 is the availability of better maternity and infant care services for high-risk mothers and infants. Amendments to the Social Security Act provided funds for the implementation, starting in 1965, of the Maternal and Infant Care Projects (MIC). This increase in federal funds earmarked for the improvement of maternal and infant health coincided with the beginning of the rapid decline in infant mortality in the United States. Morris et al. (1975:361) found that services of the MIC projects accounted for as much as 10 percent of the reduction in the nation's infant mortality rate since 1965.

The question of importance to the present study is, of course, could the two factors which served to reduce the national infant mortality also be responsible, at least in part, for the parallel decline in Louisiana? With respect to the age-parity factor, Figure 2 shows that the percent of all live births occurring in the state in the most ideal maternal-age and birth-order categories increased from 27.1 in 1965 to 39.3 percent in 1973. The racial differences shown by the chart will be discussed later in the section on differentials.

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[1] The six most favorable maternal-age and birth-order categories as cited by Wright (1972:1133) are: the first-order births to mothers 20 to 24 years of age and 25 to 29 years of age; the second-order births to mothers 25 to 29 years old and 30 to 34 years old; and the third-order births to mothers 25 to 29 years of age and 30 to 34 years of age. Those six age-parity combinations have been found to be optimal for childbirth and associated with low levels of infant mortality.

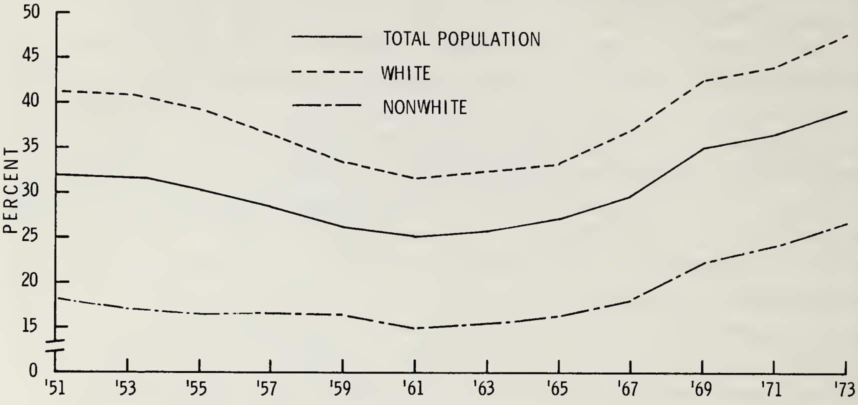

Figure 2.—Percent of All Births in the Six Most Favorable Maternal Age and Parity Categories, by Race, Louisiana, 1951 to 1973. (Source: Prepared from data in the annual volumes of the *Vital Statistics of the United States*, U.S. Department of Health, Education, and Welfare, National Center for Health Statistics, 1951, 1953, 1955, 1957, 1959, 1961, 1963, 1965, 1967, 1969, 1971, and 1973.)

Of the six most favorable maternal-age and birth-order categories, the one that has been shown in numerous other studies on various populations to exhibit the lowest infant mortality rates is the category of first-order infants born to women 20 to 24 years of age. An increase in the proportion of births in that category can have an impact in reducing infant mortality. Figure 3 shows that in Louisiana the percent of all births in this optimal age-parity category increased from 11.9 in 1965 to 16.5 in 1973.

Further evidence of the increase in the proportion of Louisiana births occurring in the lower-risk categories can be seen by examining specifically the data on birth order. According to the 1960 Birth Cohort Study (Wright, 1972:1131), infants whose mothers had previously given birth to three or more babies had a higher-than-average risk of dying before reaching their first birthday. Obviously, a decrease in the proportion of the births higher than third in birth order is likely to result in a decline in the infant mortality rate of a population. It is evident from Figure 4 that since 1965 there has been a dramatic decline in the proportion of fourth and higher order births in Louisiana, the proportion decreasing 18.2 percentage points from 33.8 in 1965 to 15.6 percent of all births in 1973.

It is apparent that one of the factors often cited as being responsible for the decline in the national rate is also operating to reduce the state's infant

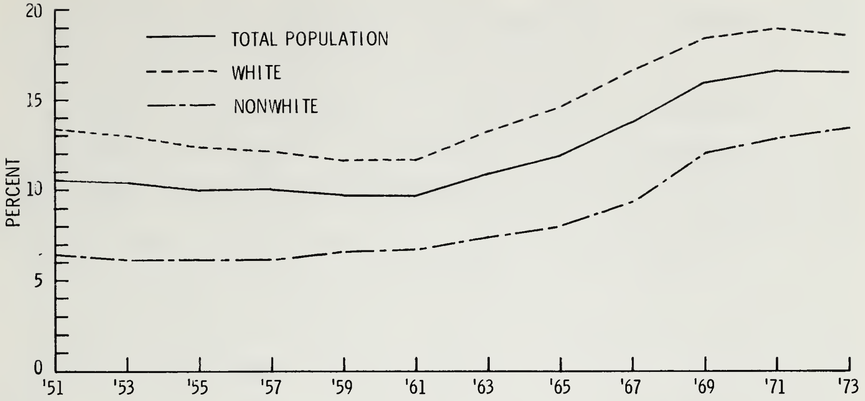

Figure 3.—Percent of All Births in the Most Favorable Maternal Age and Parity Category, by Race, Louisiana, 1951 to 1973. (Source: Prepared from data in the annual volumes of the *Vital Statistics of the United States*, U.S. Department of Health, Education, and Welfare, National Center for Health Statistics, 1951, 1953, 1955, 1957, 1959, 1961, 1963, 1965, 1967, 1969, 1971, and 1973.)

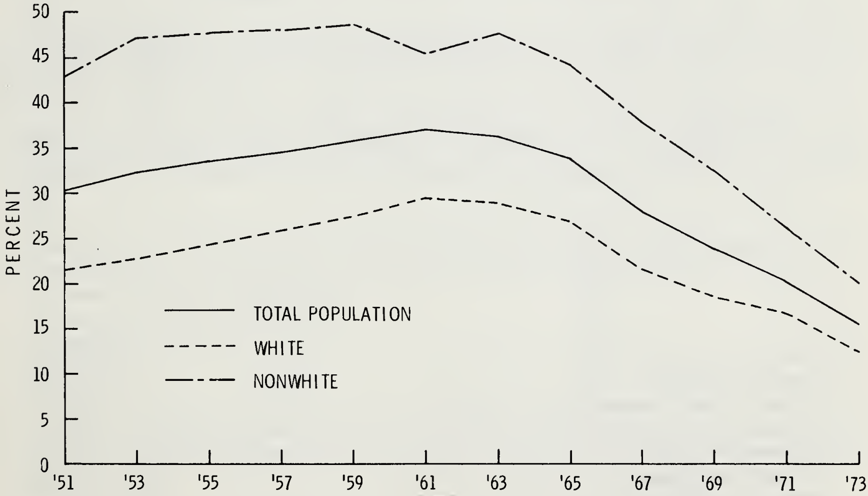

Figure 4.—Percent of All Births of a Birth Order Higher than Third, by Race, Louisiana, 1951 to 1973. (Source: Prepared from data in the annual volumes of the *Vital Statistics of the United States*, U.S. Department of Health, Education, and Welfare, National Center for Health Statistics, 1951, 1953, 1955, 1957, 1959, 1961, 1963, 1965, 1967 1969, 1971, and 1973.)

mortality levels: an improvement in the maternal age and parity conditions. As for the possible influence of the MIC projects, it can be definitely stated that they did not influence Louisiana's rate for the simple reason that they were not implemented in the state. Because of the manner in which the

Federal program was administered, Louisiana did not receive funds for MIC projects in the mid-1960s. This is not to say that the state does not have nor has ever had maternal and infant care programs. In fact, the Division of Maternal and Child Health of the State Health and Human Resources Administration was established by the legislature in 1936 with the specific purpose of implementing programs that will, among other things, reduce infant mortality in the state. The important point here is that, unlike the situation in other states, there was no increase in the influx of federal funds into Louisiana in the mid-1960s for maternal and infant care projects. Consequently, the decrease in the infant mortality rate during that period could not have been influenced by the national MIC program. Fortunately, recent changes in the Social Security Act have modified the manner in which the MIC funds are administered and have made it possible, starting in 1971, for the Louisiana Division of Maternal and Child Health to implement a number of projects in various areas of the state. These new endeavors, however, are too recent to be of relevance to the present study.[2]

REPORTED CAUSES OF DEATH

Table 2 lists the five leading reported causes of infant deaths in Louisiana during the period from 1971 to 1973. Unqualified immaturity accounted for the largest proportion of all deaths, with 11.5 percent.[3] The other four leading causes were: unspecified asphyxia of newborn, pneumonia, hyaline membrane disease, and complications of pregnancy

Table 2.—Leading Reported Causes of Infant Death, Louisiana, 1971-1973

Causes	Number of Infant Deaths	Percent
All Causes	4,411	100.0
Immaturity, unqualified	506	11.5
Asphyxia of newborn, unspecified	472	10.7
Pneumonia	390	8.8
Hyaline membrane disease	380	8.6
Complications of pregnancy and childbirth other than difficult labor	288	6.5
All Other Causes	2,375	53.9

Source: Compiled and computed from data in the Office of Public Health Statistics, *Vital Statistics of Louisiana*, Louisiana Health and Human Resources Administration, 1971 (Table XXXIII), 1972 (Table XX), and 1973 (Table XIX).

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[2] The information in the paragraph was obtained by examining the records of the Division of Maternal and Child Health and through personal communication with the staff of that office. The authors are indebted to Ms. Ruth Hofschulte of the Division for her assistance.

[3] A live birth weighing five pounds and eight ounces or less is classified as an immature birth.

and childbirth other than difficult labor.[4] Together, these five leading causes of death accounted for 46.1 percent of the total number of infant deaths occurring in the state from 1971 to 1973.

It should be noted that the five leading causes listed in Table 2 are specific causes and not the more general headings used in the International Classification of Diseases. Congenital anomalies, as a broad category, outranked the five leading specific causes of death, since it was responsible for 660 deaths, or 15 percent of all infant deaths. However, when the category is broken down into specific causes, none of them emerged as one of the five leading causes of infant death in the state.

Have there been any changes over time in the causes of infant death in Louisiana? Due to two revisions made in the classification of diseases during the period since 1950, it is a difficult task to study the trends in causes of death.[5] As Table 3 shows, from 1950 to 1952 the five leading causes of infant death were immature birth, postnatal asphyxia and atelectasis, pneumonia, congenital malformation, and injury at birth.[6] Although the top three causes of death have apparently remained the same during the 23-year period under consideration, a greater percentage of all infant deaths were attributed to these causes two decades ago (48.5) than in 1971-1973 (31.0). That lower proportion, however, may reflect not only an actual decline in the importance of those causes, but also the shifts in the

Table 3.—Leading Reported Causes of Infant Death, Louisiana, 1950-1952

Causes	Number of Infant Deaths	Percent
All Causes	7,987	100.0
Immature birth	1,931	24.2
Postnatal asphyxia and atelectasis	1,006	12.6
Pneumonia, all forms	937	11.7
Congenital malformation	816	10.2
Injury at birth	773	9.7
All Other Causes	2,524	31.6

Source: Compiled and computed from data in the Office of Public Health Statistics, *Vital Statistics of Louisiana*, Louisiana Health and Human Resources Administration, 1950 (Table XIV), 1951 (Table XVIII), and 1952 (Table XXII).

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[4] The category "complications of pregnancy and childbirth other than difficult labor" includes causes of death coded as 760, 761, 762, 763, and 769 according to the Eighth Revision of the *International Classification of Diseases, Adapted for Use in the United States*.

[5] Data on the causes of death between 1950 and 1952 were based on the Sixth Revision of the *International Classification of Diseases*, while the data for the 1971 to 1973 period were based on the Eighth Revision.

[6] "Congenital malformation" was not subdivided into specific causes in the 1950-52 data.

classification of diseases, so that caution has to be exercised in interpreting these longitudinal data on causes of death.

DIFFERENTIALS

Differential analysis has always been an important component of the study of mortality. Basically, it involves analyzing the differences in the incidence of death between various groups within a given population. The population may be divided into groups according to a number of characteristics such as age, sex, residential (urban vs. rural) status, race, socioeconomic status, etc. Differential analysis enables demographers to determine which categories of people have a higher or lower mortality risk. It also gives an indication of the social and cultural factors associated with mortality.

Studies conducted on other populations have found that infant mortality rates vary systematically according to characteristics such as the age, sex, and race of the infant, education of the mother, occupation and income of the father, rural or urban residence of the parents, and so on (Kessner et al., 1973:96-122; Shapiro et al., 1968:20-25, 64-67; Shin, 1975:1-2). We will not attempt here to study all possible differentials. Instead we will concentrate on five major ones, the analyses of which are made possible by the published data from the Louisiana Office of Public Health Statistics. These five are: sex of the infant, race of the infant, residence (metropolitan vs. nonmetropolitan) of the mother, parish of residence of the mother, and age at death. In analyzing each of these differentials, we will first examine current levels (1971-1973) and then look at the trends since 1950. Additionally, causes of death will be analyzed under the differentials of race and age.

Sex

The mortality rate for males has always been higher than that of the females for all age groups in the United States. Louisiana follows the same pattern as the rest of the nation. From 1971 to 1973, the mortality rates for male and female infants were 23.3 and 19.1 respectively. While there were 104.4 males born for every 100 females, there were 127.6 male infant deaths for every 100 female infant deaths during that period.[7]

The trends in the infant mortality rates have been very similar for both sex categories during the last two decades (see Figure 5). Both groups experienced relatively small decrements in mortality between 1950 and 1965, with sizable reductions after 1965. The gap between the male and female infant mortality rates has changed little over time. Between 1950 and 1965, the mean absolute difference in infant mortality rates between males and females was 6.7, while from 1965 to 1973 it was 5.0. The slight narrowing of the gap in the latter period can be attributed to a sharper decline of the male rate in comparison with the rate for females. From 1967 to 1971 the percent decline was 18.6 for the males and 14.1 for the females. However, the trend in the direction of a convergence of the sex differential did not persist. The gap began to widen again after 1971. It is apparent that the convergence was only a short-term phenomenon.

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[7] It is interesting that the ratio of male deaths to female deaths was higher among whites as compared to nonwhites in Louisiana. The sex ratios at birth for the whites and nonwhites were 105.0 and 103.4, respectively, yet whites had a much higher ratio of 134.9 male infant deaths per 100 female infant deaths compared to the nonwhite ratio of 120.7.

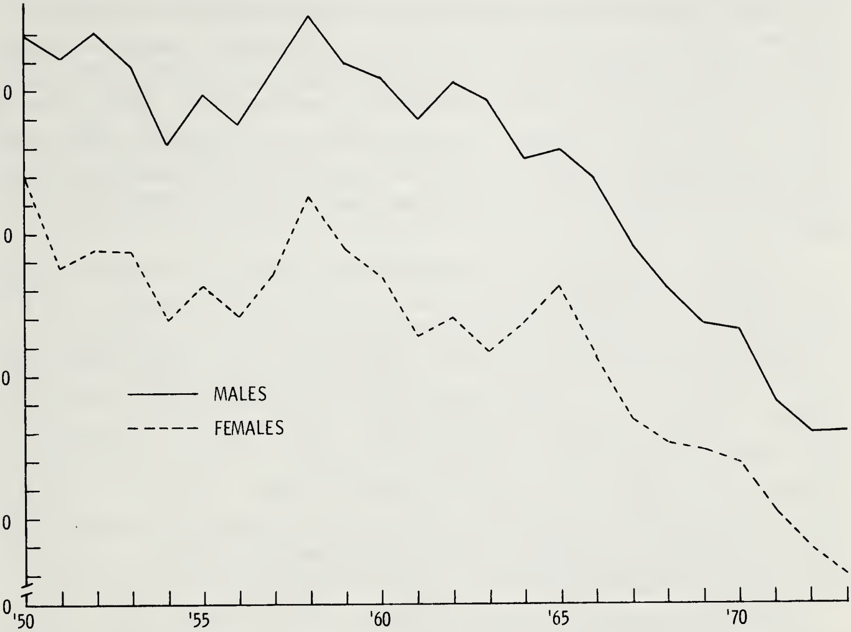

Figure 5.—Infant Mortality Rates by Sex, Louisiana, 1950 to 1973. (Source: Prepared from data in the annual volumes of *Vital Statistics of Louisiana*, Louisiana Health and Human Resources Administration, the Office of Public Health Statistics, 1950 to 1973.)

Race

Previous studies have shown that nonwhites throughout the nation have higher infant mortality rates than whites (Kessner et al., 1973:15; Shapiro et al., 1968:23-25; Shin, 1975:2). Louisiana is no exception. From 1971 to 1973 the nonwhite infant mortality rate was 27.3 compared to a rate 17.4 for whites.[8]

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[8] Since 99 percent of the nonwhites in Louisiana are black, the data presented for nonwhites are essentially data on blacks.

What are the factors contributing to this racial differential in infant mortality? Previous studies on other populations have shown that a disproportionate number of nonwhite births occur to mothers of high-risk status. A New York study conducted by Kessner and his associates (1973:3) found that three-fourths of the black native-born mothers were in the high-risk categories, while only slightly more than one-third of the white native-born mothers could be categorized as "high-risk."

What are the characteristics of the so-called "high-risk" mothers? High-risk mothers generally belong to age groups at both ends of the childbearing period: the 15 to 19 and the 35 to 45 age groups. They usually have a high number of prior births and short intervals between births. The relationship between the mother's repeated pregnancies coupled with short birth intervals and high infant mortality has been well established (Connell, 1976:12; Planned Parenthood Federation of America, 1975:147-148; Hibbs, 1916:39-44). Repeated pregnancies and prolonged lactation put a drain on the mother's proteins, calcium, and iron, thus affecting her ability to bear infants that are healthy enough to survive the critical first year of life.

Using the age of the mother and birth order (the latter being equivalent to the number of babies the woman has ever given birth to) as the criteria for identifying the incidence of births to high-risk mothers in Louisiana, it was found that more nonwhite than white infants were born to high-risk mothers in 1973. That year, 33.3 percent of all births classified as nonwhite had mothers between 15 and 19 years of age, while only 19.3 percent of all white infants had mothers in that age category. At the other end of the childbearing period, 5.7 percent of the nonwhite infants were born to women 34 years of age and over, whereas 4.5 percent of the white infants fell in this category. As for the proportion of fourth and higher order births, the figure for nonwhites was 62.4 percent higher than that for whites.

The relationship between the risk status of the mother and the survival of the infant can be affected by the intervening variable of health care, which includes the amount and quality of medical attention received by the mother and infant both before and after the birth. The combined effect of the high-risk status of the mother and inadequate medical attention has a highly negative impact on the survival chances of the infant. Since a disproportionate share of the nonwhites in Louisiana are in the lower socioeconomic stratum, many of them lack the knowledge and financial resources to provide adequate care for their offspring.

The higher mortality of nonwhite infants is also a result of a high proportion of them being of low birth weight (less than 2,500 grams or five pounds and eight ounces), which itself is a consequence of the health and maternal factors just discussed. Numerous studies (Kessner et al., 1973:114-115; Shapiro et al., 1968:51-53) have established a strong inverse relationship between birth weight and infant mortality. The incidence of death among infants of low birth weight has been found to be as high as 17 times the mortality of infants of normal birth weight. In Louisiana, during the period from 1971 to 1973, 13.2 percent of the births categorized as nonwhite were of low weight, compared with 6.5 percent of the births classified as white.

The relatively high incidence of illegitimate births among the nonwhites in Louisiana has also contributed to the racial differential in infant mortality. Findings from previous studies (Kessner et al., 1973:113-114; Shapiro et al., 1968:58, 65-67) suggest that, overall, an illegitimate infant has a slimmer chance than other infants of reaching his or her first birthday. The incidence of illegitimacy is particularly high among infants born to women who are between the ages of 15 and 19, the maternal ages during which the probability of giving birth to an infant of low birth weight is relatively high. In Louisiana, only 4.3 percent of all white infants born from 1971 to 1973 were illegitimate. In contrast, 37.1 percent of all nonwhite infants born during the same period had unmarried mothers.

Has the gap between white and nonwhite infant mortality always been the same over time? It is evident from Figure 6 that although nonwhites

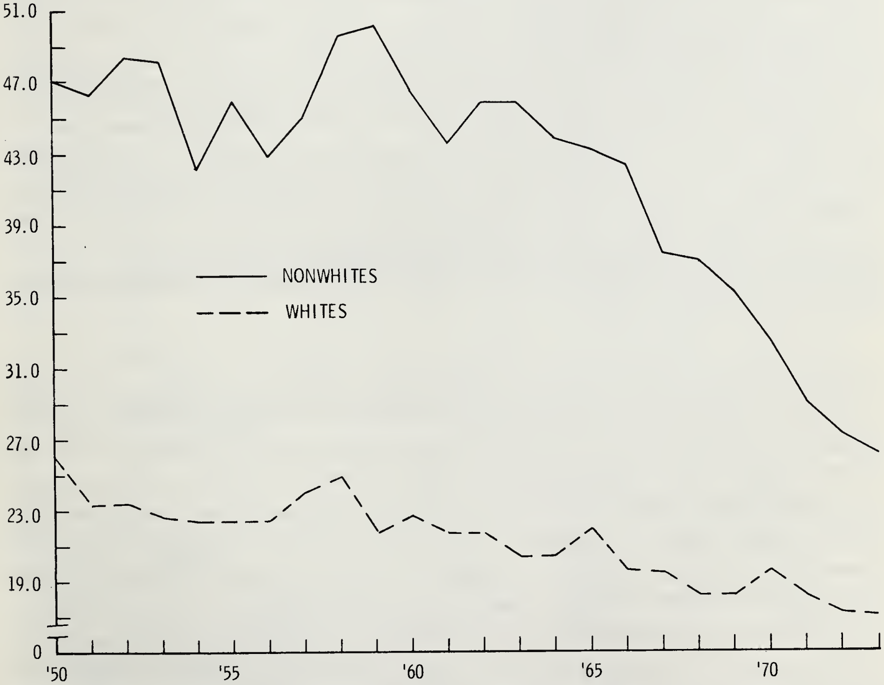

Figure 6.—Infant Mortality Rates by Race, Louisiana, 1950 to 1973. (Source: Prepared from data in the annual volumes of *Vital Statistics of Louisiana,* Louisiana Health and Human Resources Administration, the Office of Public Health Statistics, 1950 to 1973.)

have exhibited higher mortality rates than whites since 1950, the gap has narrowed. In 1950, nonwhites had an infant mortality rate of 47.0, while their white counterparts experienced a relatively moderate loss of 26.0. The gap was widest in 1959, when the infant mortality rates were 50.2 for nonwhites and 21.7 for whites, a difference of 28.5. After 1965 the differential between the racial groups began to narrow, so that by 1973 nonwhites exceeded whites in their infant mortality rates by only nine deaths per thousand live births. The trend since 1966 in the direction of a convergence of the differential was due to an acceleration in the infant mortality decline among nonwhites. Although white infants also experienced a decrease in mortality during the same period, their reduction was less impressive than that of the nonwhites.

What factors are associated with a greater decline of nonwhite infant mortality which resulted in a narrowing of the racial differential after 1965? An examination of Figures 2, 3, and 4, previously presented, may yield some insights. Figures 2 and 3 present, by race, the trends in the proportion of all births in the most desirable and optimal age-parity categories. An examination of the two figures indicates that while both racial groups show a definite trend towards a more favorable age-parity situation, the proportions for the nonwhite population did not register noticeably greater improvements than the figures for the white population. All lines on each of the two graphs, in fact, are practically parallel to each other. When we turn to Figure 4, however, and examine only the birth-order situation, we find that since 1965 the decrease in the proportion of births of a birth order higher than third is more pronounced among nonwhites than among whites. While the percent for whites decreased from 26.8 percent in 1965 to 12.5 percent in 1973 (a reduction of 14.3 percentage points), the figure for the nonwhite population dropped from 44.2 to 20.3 percent, an improvement of 23.9 percentage points.

It appears, then, that the situation with respect to racial differentials can be summarized as follows. In the early 1970s nonwhites still had a more unfavorable situation than whites, with more high-risk mothers and a greater proportion of high-order births. Looking at trends, since 1965 an increasing proportion of both white and nonwhite women are having their first three births in the most favorable maternal ages. Both racial groups are effecting that improvement at an equal rate. In terms of numbers of births, however, nonwhite women are reducing the proportion of births in the higher birth orders (fourth or more) at a faster rate than white women. Undoubtedly, this faster rate of improvement in the birth-order situation is a major factor responsible for the more rapid rate of decline which the nonwhite infant mortality rate is exhibiting since 1965 and which has resulted in a narrowing of the gap between the rates of the two races. This analysis does not, of course, rule out the possible influence of other factors, such as substantial improvements since 1965 in the socioeconomic status and levels of health care of the nonwhite population, which may also account for the drop in their rate.

Before concluding this section on racial differentials, it would be of interest to compare the leading reported causes of death of the two racial groupings. Tables 4 and 5 present the five leading specific causes of infant death for whites and nonwhites, respectively. Three causes are found in both lists: asphyxia of newborn, immaturity, and hyaline membrane disease. These accounted for 33.8 percent of all white infant deaths and 27.7 percent of all nonwhite infant deaths. The other two causes of death on the list for the white population are congenital anomalies of the heart (a specific category of congenital anomalies), and respiratory distress syndrome. Pneumonia and "complications of pregnancy and childbirth other than difficult labor" complete the quinary list for nonwhites.

The fact that pneumonia was the second most important cause of nonwhite infant death, without even appearing on the list for whites, indicates

Table 4.—Leading Reported Causes of Death Among White Infants, Louisiana, 1971-1973

Causes	Number of Infant Deaths	Percent
All Causes	2,213	100.0
Asphyxia of newborn, unspecified	274	12.4
Immaturity, unqualified	250	11.3
Hyaline membrane disease	224	10.1
Congenital anomalies of heart	164	7.4
Respiratory distress syndrome	151	6.8
All Other Causes	1,150	52.0

Source: Compiled and computed from data in the Office of Public Health Statistics, *Vital Statistics of Louisiana*, Louisiana Health and Human Resources Administration, 1971 (Table XXXIII), 1972 (Table XX), and 1973 (Table XIX).

Table 5.—Leading Reported Causes of Death Among Nonwhite Infants, Louisiana, 1971-1973

Causes	Number of Infant Deaths	Percent
All Causes	2,198	100.0
Immaturity, unqualified	256	11.6
Pneumonia	252	11.5
Asphyxia of newborn, unspecified	198	9.0
Hyaline membrane disease	156	7.1
Complications of pregnancy and childbirth other than difficult labor	151	6.9
All Other Causes	1,185	53.9

Source: Compiled and computed from data in the Office of Public Health Statistics, *Vital Statistics of Louisiana*, Louisiana Health and Human Resources Administration, 1971 (Table XXXIII), 1972 (Table XX), and 1973 (Table XIX).

that exogenic and environmental hazards are still playing an important part in causing infant deaths among nonwhites in Louisiana. This is consistent with the findings of the study by Shapiro et al. (1968:23) that the racial differential is relatively small shortly after birth but widens as postnatal environmental conditions become the dominant factors. Since exogenous mortality is often viewed as preventable, the reduction of deaths from exogenous causes through better health care can substantially suppress the number of nonwhite infant deaths.

Residence

A comparison of infant mortality rates during the 1971-1973 period by metropolitan residence is shown in Table 6. Infants whose mothers' usual place of residence is in the metropolitan parishes had a lower mortality rate (20.4) than those from the nonmetropolitan parishes (22.3).[9] Within the category of nonmetropolitan parishes, however, infant mortality rates varied according to the proximity to metropolitan areas. Nonmetropolitan parishes adjacent to the S.M.S.A.s were characterized by an infant mortality rate (21.0) lower than that of the nonadjacent parishes (24.4) and the state as a whole (21.2).[10]

Table 6.—Infant Mortality by Residence, Louisiana, 1971-1973

Residential Categories	Number of Infant Deaths	Number of Live Births	Infant Mortality Rate
Total	4,411	207,767	21.2
Metropolitan parishes	2,362	115,931	20.4
Nonmetropolitan parishes	2,049	91,836	22.3
Adjacent parishes	1,192	56,745	21.0
Nonadjacent parishes	857	35,091	24.4

Source: Compiled and computed from data in the Office of Public Health Statistics, *Vital Statistics of Louisiana*, Louisiana Health and Human Resources Administration, 1971 (Tables VII and XXXV), 1972 (Tables III and XIX), 1973 (Tables I and XVIII).

Figure 7 presents the trends in residential differentials since 1950. Throughout the last two decades, both categories of nonmetropolitan parishes have experienced higher infant mortality rates than metropolitan parishes.[11] The margin between the metropolitan and nonmetropolitan categories, however, has undergone some changes. It was widest in the first half of the 1950 decade. Since then, the gap has narrowed, with the exception of the brief period from 1967 to 1969.

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[9] Parishes categorized as metropolitan are those within areas designated by the U.S. Bureau of the Census as Standard Metropolitan Statistical Areas. S.M.S.A.s contain at least one parish with a city of 50,000 or more inhabitants and may also include adjoining parishes. Ten parishes in the state were categorized as metropolitan in 1970. These were: Caddo, Bossier, Calcasieu, Lafayette, Ouachita, East Baton Rouge, Orleans, Jefferson, St. Bernard, and St. Tammany.

[10] Nonmetropolitan adjacent parishes are those not contained within, but which are contiguous to, S.M.S.A.s. There were 33 such parishes in Louisiana in 1970. Twenty-one parishes were categorized as nonmetropolitan nonadjacent.

Regarding the rate of decline, the 23-year span can be divided into two distinct periods with 1965 once again as the key year. Between 1950 and 1965, little improvement was attained. Metro parishes declined 11.6 percent while all nonmetropolitan parishes declined 9.7 percent. From 1965 to 1973, however, high percentage changes of 31.5 for metro parishes and 33.5 for all nonmetropolitan parishes were recorded.

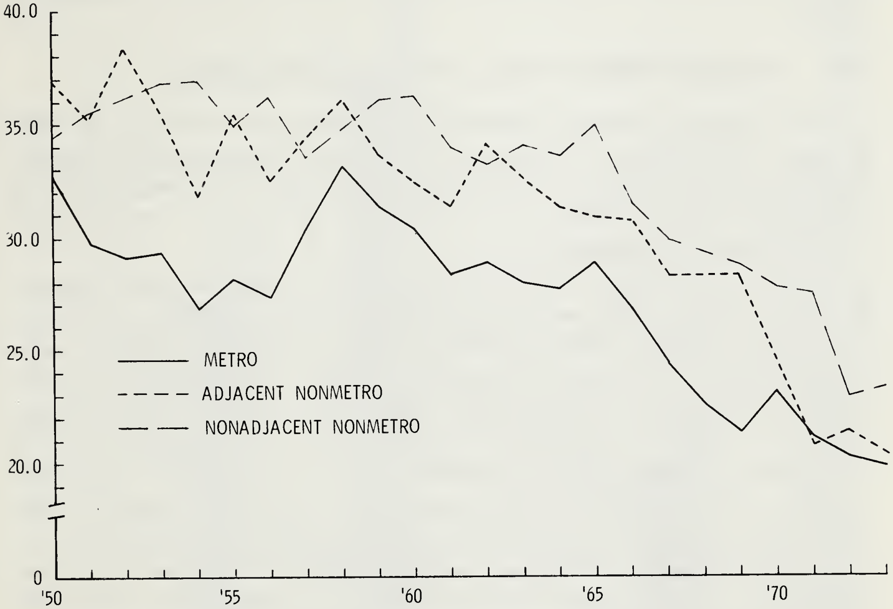

Figure 7.—Infant Mortality Rates by Residence, Louisiana, 1950 to 1973. (Source: Prepared from data in the annual volumes of *Vital Statistics of Louisiana*, Louisiana Health and Human Resources Administration, the Office of Public Health Statistics, 1950 to 1973.)

A closer look at the period from 1965 to 1973 enables us to see an interesting pattern of change among the various residential groups. From 1965 to 1969, the metropolitan areas exhibited the most sizable decline (24.5 percent), with the nonmetropolitan nonadjacent parishes second

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[11] The number of metropolitan parishes in Louisiana increased from five to ten between 1950 and 1960, but remained the same between 1960 and 1970. The infant mortality rates of the various residential categories in Figure 7 are based on the 1960 and 1970 census classification of metropolitan parishes regardless of whether or not the parishes were metropolitan in 1950.

(14.3), while the nonmetropolitan adjacent parishes attained the smallest amount of decline (6.4). However, from 1969 to 1973, the speed of the decline in the three residential categories was reversed, with the nonmetro adjacent parishes experiencing the greatest decrease (27.3 percent), the nonadjacent parishes an intermediate rate of decline (19.1), and the metropolitan parishes the smallest decline (7.0). As a result of these recent patterns, the gap between metropolitan and all nonmetropolitan areas was slightly widened from 1967 to 1969, and narrowed again in the subsequent years. The improvement exhibited by the nonmetropolitan adjacent parishes after 1969 means that for the first time since 1950 their rates were more similar to the metropolitan ones than to the levels for nonadjacent parishes.

The Combined Effect of Sex, Race, and Residence

After having examined separately the differentials of sex, race, and residence, it would be of interest to analyze the combined effect of those attributes on the incidence of infant mortality. Figure 8 has been drawn for that purpose. Each of the 12 bars on the graph represents a combined sex, race, and residence category.

As we would expect, nonwhite male infants living in the nonmetropolitan nonadjacent parishes recorded the highest infant mortality rate (34.1), while white female infants residing in the metropolitan parishes were characterized by the lowest infant mortality rate (14.6). Our earlier finding that male infants had a consistently higher death rate than female infants holds true when the comparison is made within each race group. Figure 8 shows that white male infants, regardless of where they reside, had higher mortality rates than their female counterparts. Similarly, nonwhite male infants had a higher rate of mortality than nonwhite female infants in each of the corresponding residential categories. But the influence of the sex differential is almost inconsequential when race is introduced. This can be illustrated by pointing out that nonwhite female infants had higher mortality rates than white infants of the male sex regardless of residential category. Furthermore, the lowest infant mortality rate of nonwhite infants (23.6), experienced by the nonwhite females residing in the metropolitan parishes, was still higher than the highest mortality rate of whites (22.7), exhibited by the white male infants living in the nonmetropolitan nonadjacent parishes.

The effect of residential status can be clearly seen when the influence of sex and race is held constant. Within each sex-race category, infants from nonmetropolitan nonadjacent areas consistently had higher mortality rates than those residing in the other two categories. Metropolitan infants of each sex-race group experienced the lowest mortality rates. The only exception to that pattern was found among nonwhite male infants, with those in the adjacent parishes having a better chance for survival than those residing in

S.M.S.A.s. Once again, the influence of the residential variable diminished when race was introduced. Both male and female infants of the white race living in the nonmetropolitan nonadjacent parishes had lower infant mortality rates (22.7 and 16.7, respectively) than nonwhite infants of both sexes in their most favorable residential categories (27.6 and 23.6).

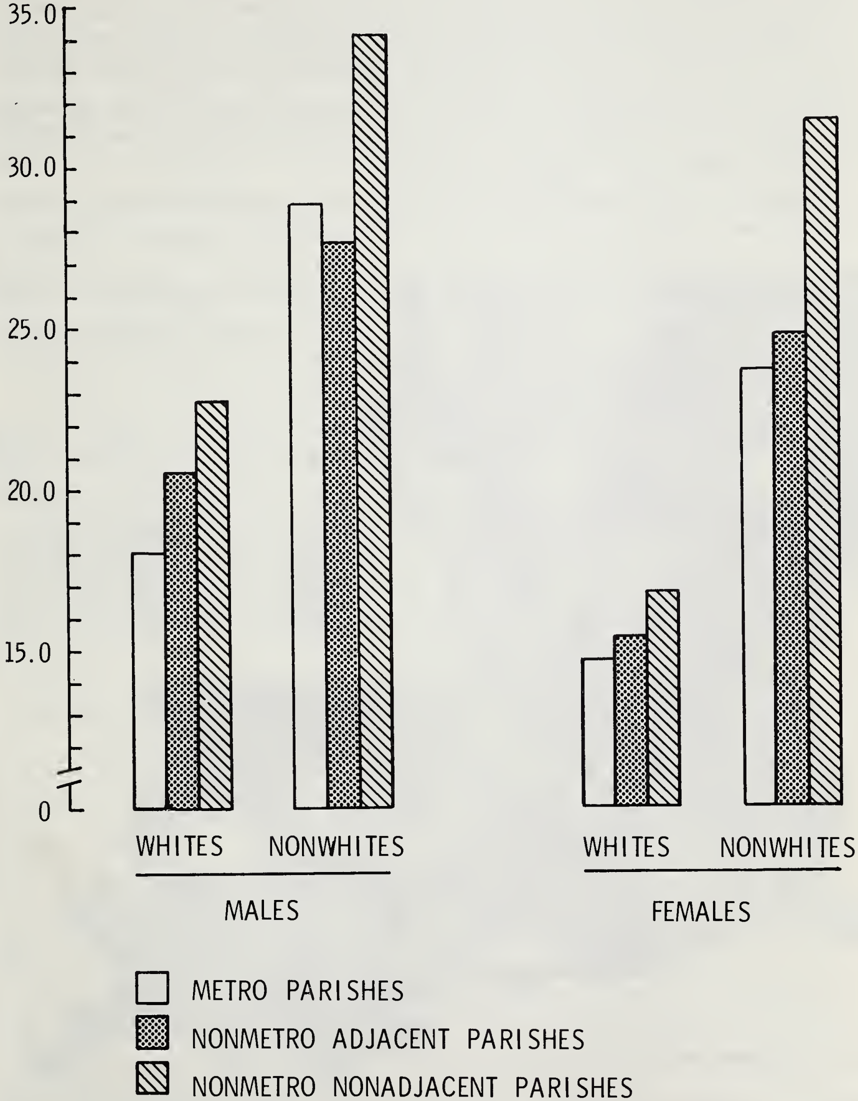

Figure 8.—Infant Mortality Rates by Sex, Race, and Residence, Louisiana, 1971 to 1973. (Source: Prepared from data in the *Vital Statistics of Louisiana*, Louisiana Health and Human Resources Administration, the Office of Public Health Statistics, 1971 (Tables VII and XXXV), 1972 (Tables III and XIX), 1973 (Tables I and XVIII).)

Parish

One differential frequently examined by mortality analysts is that which involves dividing the population according to their residence in the various civil-administrative divisions and examining the differences in mortality between those geo-political units. For a state, the most appropriate sub-units for such an analysis are the counties, called parishes in Louisiana. An understanding of parish differentials has important implications. For instance, health care funds, facilities, and personnel are frequently administered at the parish level. State and local officials involved in the planning and distribution of health care therefore need to be informed about the levels of mortality by parish.

Figure 9 has been drawn in order to present, in graphic form, an overview of the state in the period from 1971 to 1973 in terms of variations

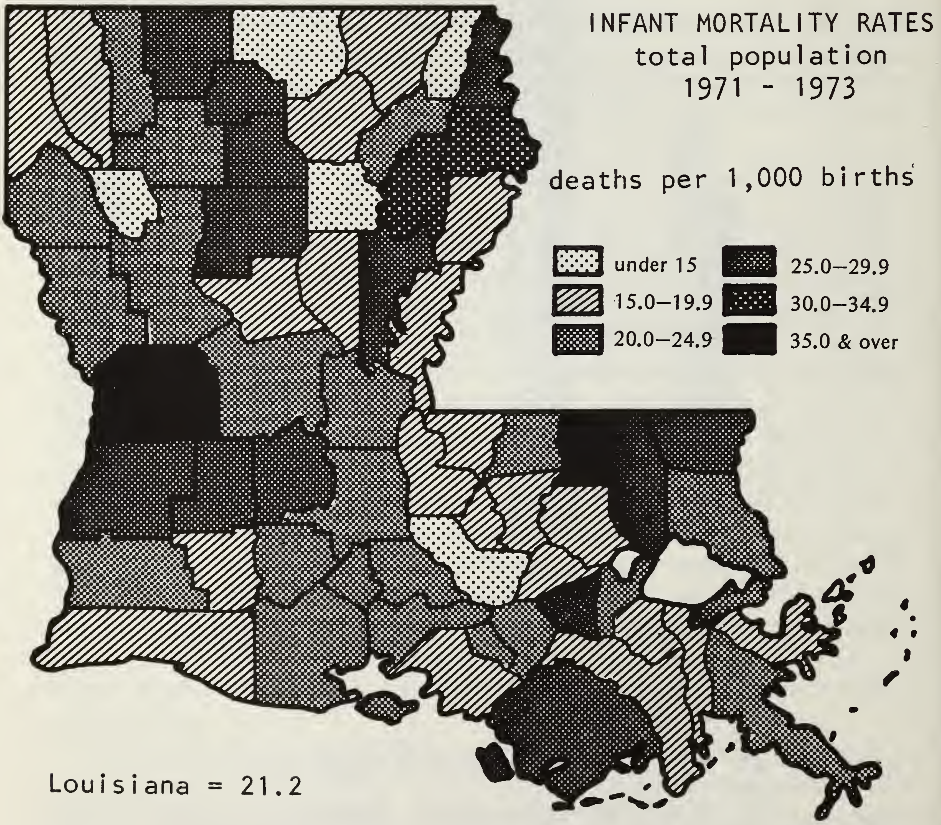

Figure 9.—Infant Mortality Rates by Parish, Louisiana, 1971 to 1973. (The specific rate for each parish is shown in Table 7.) (Source: Prepared from data in the *Vital Statistics of Louisiana*, Louisiana Health and Human Resources Administration, the Office of Public Health Statistics, 1971 (Tables VII and XXXV), 1972 (Tables III and XIX), 1973 (Tables I and XVIII).)

among the 64 parishes in their infant mortality rates. The figures used in constructing Figure 9 are shown in the first column of Table 7. The rates ranged from a high of 47.1 for Vernon Parish to a low of 10.8 for Caldwell. While St. Landry had exactly the same rate as the state (21.2), 31 parishes had infant mortality rates above the Louisiana rate, and 32 parishes had rates below 21.2. Of the four parishes that had the highest infant mortality rates, three (Vernon, Madison, and Franklin) were nonmetropolitan nonadjacent parishes, while St. Helena and Madison had disproportionately large nonwhite populations (56.7 and 60.9 percent, respectively). On the other hand, the five parishes that reported the lowest infant mortality rates were all adjacent to various S.M.S.A.s, with the exception of West Carroll. The relatively low percentage of nonwhites (19.5) in that parish presumably explains, at least in part, its low level of infant mortality. Among the 10 metropolitan parishes, the rates ranged from 24.6 (Orleans and St. Tammany) to 17.5 (East Baton Rouge). Three of those 10 parishes had rates above the state (Orleans, St. Tammany, and Lafayette) while the rest had rates below the Louisiana rate.

It is apparent from Figure 9 that there is no obvious pattern of concentration of either high or low levels of infant mortality in any part of the state. High rates as well as low rates are dispersed throughout the state, with no evident tendency to cluster in particular areas.

While the range of the parish rates is about 37 deaths per 1,000, Figure 9 shows that an overwhelming proportion of the parishes are grouped around the lower-middle level of that range. Fifty-five of the 64 parishes had rates that fell within just three of the six categories utilized in the legend of Figure 9, i.e., rates between 15.0 and 29.9. In fact, 42 parishes were within the even smaller range of 15.0 to 24.9.

What have been the trends in parish differentials since 1950? Fortunately, an earlier bulletin of the Louisiana Agricultural Experiment Station by Hitt and Price (1954) included a map for the period from 1949 to 1951 comparable to that in Figure 9. That map is reproduced here as Figure 10. The rates utilized by Hitt and Price in drawing the map can be found in the third column of Table 7.

An examination of Figures 9 and 10 and the rates in Table 7 yields three major conclusions about changes since 1949-51. The first one is obviously not surprising: overall, the rates have declined substantially. In order to draw Figure 9, the legend had to be considerably lower than that used in the 1949-51 map. If the categories utilized in the older figure had been employed in the 1971-73 map, 60 of the 64 parishes would have fallen in the lowest category (under 30.0).

The second observation is that, along with the overall decline in the rates, there has been a decrease during the past two decades in the size of the range of the rates. In contrast to the 37 deaths per thousand that separated the highest and lowest rates in the 1971-73 period, more than 50

Table 7.—Infant Mortality Rates by Parish, Louisiana, 1971-1973 and 1949-1951

	1971-1973		1949-1951	
Parishes	Rate	Rank	Rate	Rank
Vernon	47.1	1	40.7	21
St. Helena	37.2	2	25.3	56
Madison	33.7	3	50.6	5
Franklin	33.3	4	38.6	26.5
Catahoula	29.5	5	24.3	59
Lincoln	29.3	6	30.6	46.5
Evangeline	28.6	7	44.3	14
Claiborne	27.6	8	48.0	9
East Carroll	27.4	9	36.1	32
Allen	27.3	10	30.1	49.5
Washington	27.2	11	34.6	37
Tangipahoa	27.1	12	29.3	51
Winn	26.8	13	24.6	58
St. James	26.5	14	48.5	8
Jackson	26.4	15	36.0	33
Terrebonne	26.1	16	32.5	42
Beauregard	25.3	17	37.7	28
DeSoto	24.6	19	45.8	13
Orleans	24.6	19	28.5	52
St. Tammany	24.6	19	30.6	46.5
Sabine	24.3	21	31.7	44
East Feliciana	24.2	22	35.6	34
Avoyelles	23.3	23	27.3	53.5
Plaquemines	23.2	24.5	33.7	40
Richland	23.2	24.5	51.1	4
Natchitoches	23.1	26	42.1	17.5
St. Martin	22.9	27	41.0	20
Vermilion	22.0	28	32.1	43
St. John	21.8	29	49.7	6
Acadia	21.5	30	41.3	19
Lafayette	21.4	31	46.2	11
St. Landry	21.2	32	51.9	3
Webster	21.1	33	38.6	26.5
Bienville	20.9	34	39.6	23
Calcasieu	20.8	35	34.1	38
Assumption	20.7	36.5	39.4	24
Iberia	20.7	36.5	42.7	16
Rapides	20.5	38	37.4	29
LaSalle	19.9	39	21.8	62
Pointe Coupee	19.7	40	43.5	15
St. Mary	19.6	41	37.2	30
Grant	18.5	42	23.9	60
St. Bernard	18.3	43	27.3	53.5
Ouachita	18.2	44.5	39.1	25
St. Charles	18.2	44.5	21.6	63
Jefferson	18.1	46	20.1	64
Concordia	18.0	47.5	46.0	12
West Baton Rouge	18.0	47.5	52.7	2
Cameron	17.9	49	37.0	31
Caddo	17.7	50	40.3	22
Bossier	17.5	51.5	30.1	49.5
East Baton Rouge	17.5	51.5	25.3	56

(Continued)

Table 7 (Continued)

	1971-1973		1949-1951	
Parishes	Rate	Rank	Rate	Rank
Morehouse	17.4	53	42.1	17.5
Tensas	17.3	54	30.5	48
Jefferson Davis	16.8	55.5	35.4	35.5
Lafourche	16.8	55.5	35.4	35.5
Livingston	16.1	57	23.4	61
Ascension	15.3	58	34.0	39
West Feliciana	15.0	59	49.0	7
Iberville	13.5	60	47.7	10
Union	13.3	61	30.7	45
Red River	12.6	62.5	70.3	1
West Carroll	12.6	62.5	32.7	41
Caldwell	10.8	64	25.3	56

Source: The 1971-1973 figures are computed from data in the Office of Public Health Statistics, *Vital Statistics of Louisiana*, Louisiana Health and Human Resources Administration, 1971 (Tables VII and XXXV), 1972 (Tables III and XIX), 1973 (Tables I and XVIII). The 1949-1951 figures are obtained from Homer L. Hitt and Paul H. Price, *Health in Rural Louisiana at Mid-Century*, Bulletin No. 492, Louisiana Agricultural Experiment Station, 1954, Appendix, pp. 62-63.

deaths per thousand separated the two extreme rates for the 1949-51 period (70.3 for Red River and 20.1 for Jefferson).

A final observation that can be made concerning the trends in parish differentials is that there have been tremendous changes in the rates for many parishes, with the result that the relative standing of the parishes according to their level of infant mortality in 1949-1951 bears practically no resemblance to their relative positions in 1971-1973. This can be more readily appreciated by looking at columns 2 and 4 of Table 7, which present the rank order of parishes in 1971-73 and 1949-51, respectively. A rank of 1 represents the highest rate among all the parishes and a rank of 64 the lowest. Even a cursory examination of the two columns reveals that there have been great alterations in the rankings of many parishes during the period in question. The application of a statistical technique that is used to measure the correspondence between two sets of ranks, Spearman's Rho, confirms such an observation. The value of the Rho coefficient may vary from a maximum of +1.0, indicating identical sets of ranks, to −1.0 in the case of a perfect reversal of ranks. A coefficient of 0.0 means that there is no relationship at all between the two ranked groups. The computed Rho coefficient of the columns of ranks in Table 7 is −0.02.

The tremendous alterations between 1949-1951 and 1971-1973 in the rates and ranks of many of the parishes can best be pointed out by looking at some of the more extreme cases. Red River Parish, which had the highest infant mortality rate in 1949-1951 (70.3), exhibited the third lowest rate in 1971-1973 (12.6), thereby experiencing an improvement of 82.1 percent during the 20-year period. Four other parishes achieved an improvement of 60 percent or better in their infant mortality levels. These were: Iberville

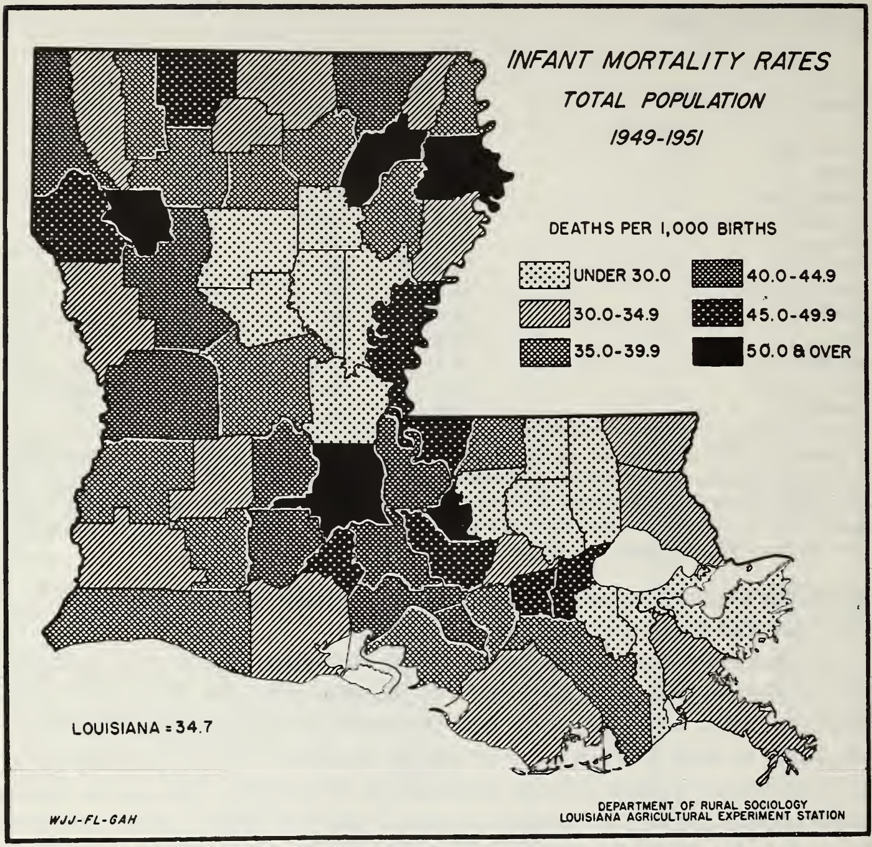

Figure 10.—Infant Mortality Rates by Parish, Louisiana, 1949 to 1951. (The specific rate for each parish is shown in Table 7.) (Source: Reproduced from Homer L. Hitt and Paul H. Price, *Health in Rural Louisiana at Mid-Century*, Bulletin No. 492, Louisiana Agricultural Experiment Station, 1954, p.42.)

(71.7%), West Feliciana (69.4%), West Baton Rouge (65.8%), and Concordia (60.8%). Not all of the changes, however, were in the direction of lower levels of infant mortality. There were four parishes in Louisiana whose rates actually increased during this period: St. Helena, Catahoula, Vernon, and Winn. The first one is particularly noteworthy: St. Helena's rate increased 47 percent, with the consequence that after occupying an enviable rank of 56 in 1949-1951, twenty years later it exhibited the second highest rate in the state. The reasons for the increase in the rates of those four parishes are not readily apparent.[12] Future research should focus on the factors associated with these increases, as well as on the conditions responsible for the impressive improvements recorded in other parishes.

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[12] There were no substantial increases in the proportion of nonwhites in these parishes between 1950 and 1970.

Age at Death

Previous studies on other populations have extensively documented the existence of differentials in the incidence of infant death according to the age of the infant (Bouvier and van der Tak, 1976: 16-17; Chandrasekhar, 1972:169-172). The chances of dying are not evenly distributed throughout the first year of life. Overall, the younger the infant, the higher the risk of death (Kessner et al., 1973:97).

For analytical purposes, demographers have found it meaningful to study the variations in incidence of death within the first year of life by making a basic distinction between the neonatal and postneonatal periods. The former is limited to the first month of life (27 days or less), and the latter encompasses the remainder of the year, from one to 11 months. Despite the fact that the neonatal period represents a shorter span of time than the postneonatal period, it accounts for a greater share of the infant deaths occurring in most modern Western societies. Such has been the case in the United States since at least 1950 (Bouvier and van der Tak, 1976:16).

In Louisiana, the level of neonatal deaths substantially exceeded postneonatal mortality during the period from 1971 to 1973. The rate for the former was 15.9 deaths per 1,000 live births while the rate for the latter was 5.3.[13] In fact, if we divide further the neonatal period, we find that the rate for those dying within the first 24 hours was 9.4, while those dying after the first day and before 27 days exhibited a rate of 6.5 per thousand live births. Another way of expressing these data is to indicate that of the 4,411 total infant deaths in the state from 1971 to 1973, 1,961, or 44.4 percent, occurred to infants under one day of age. In contrast, 1,352, or 30.7 percent of all infant deaths, occurred to infants whose ages were in the remainder of the neonatal period (1-27 days of age), and 1,098, or 24.9 percent, were postneonatal deaths. Clearly, the closer to the time of the birth, the higher the incidence of mortality.

Although a much higher neonatal than postneonatal rate prevailed in the state during the 1971 to 1973 period, this has not always been the case. Figure 11 presents the trends in neonatal and postneonatal mortality since 1950. The neonatal period is divided into deaths to infants under one day of age and from one to 27 days of age. In 1950, postneonatal deaths already exhibited the lowest levels, but only very slightly: 11.1 as compared to 11.7 and 11.6 for the other two categories. It is clear, however, that from 1950 to 1973, postneonatal deaths declined at a faster rate than the neonatal rates, dropping 52 percent from 11.1 to 5.3. By comparison, the rate for under one day dropped only 35 percent and the rate for one to 28 days decreased 43 percent. The graph also indicates that despite the overall trend towards a decline, there have been tremendous fluctuations from year to

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[13] Obviously, the sum of the neonatal and postneonatal rates is the same as the total infant mortality rate (21.2).

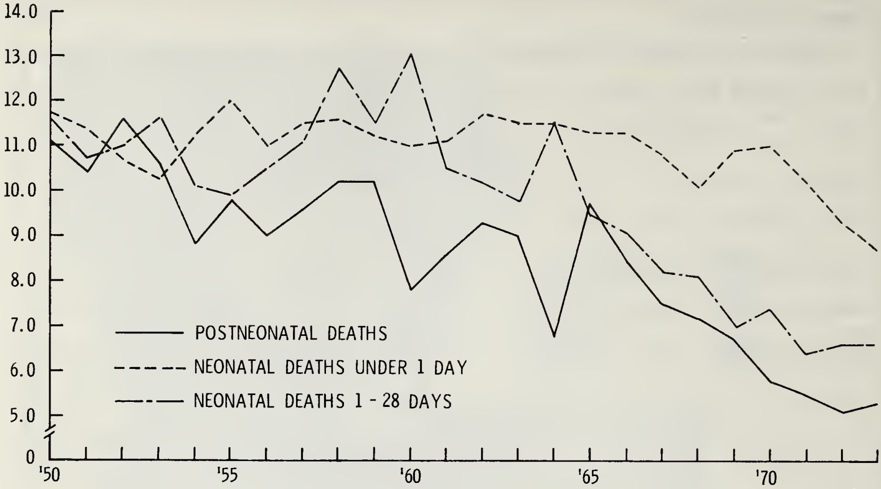

Figure 11.—Infant Mortality Rates by Age, Louisiana, 1950 to 1973. (Source: Prepared from data in the annual volumes of *Vital Statistics of Louisiana*, Louisiana Health and Human Resources Administration, the Office of Public Health Statistics, 1950 to 1973.)

year: only the rate for infants who died in less than 24 hours remained fairly stable throughout the 23-year period. The year 1965 once again emerges as a key year; not only do the postneonatal and late neonatal rates decline more precipitously thereafter, but also the early neonatal rate does not decline at all until after the mid-sixties.

An examination of the leading causes of death in each of those three age categories is basic to an understanding of the factors associated with the differential levels and trends that have just been observed. Endogenous causes of death (those that originate while the infant is a fetus or in the process of being born) are generally responsible for the vast proportion of neonatal deaths, especially those under one day of age. Postneonatal deaths, however, are usually caused by environmental (exogenous) factors (Bouvier and van der Tak, 1976:13). Consequently, the level of postneonatal deaths is susceptible to improvements in the treatment of infectious and contagious diseases and is likely to have experienced notable decreases in the last few decades, when many diseases of that nature were brought under control. In contrast, deaths caused by endogenous factors are not as preventable, at least given current levels of medical technology, and are therefore not as likely to have declined as significantly as postneonatal deaths. This is especially true of deaths to infants who only live for a few hours (Shapiro et al., 1968:16-17).

For Louisiana, Tables 8, 9, and 10 confirm the existence of marked contrasts in the causes of infant deaths according to age at death. As expected, all of the leading causes of death for babies who died within 24 hours of birth (Table 8) can be definitely labeled as endogenous: immaturity, asphyxia of newborn, complications of pregnancy and childbirth other than difficult labor, hyaline membrane disease, and respiratory distress syndrome. Together, these five accounted for 65.3 percent of all early neonatal deaths. It should be mentioned once again that the broad category of "congenital anomalies" was also a leading cause when viewed as a broad category (10.7 percent of all early neonatal deaths), but that no specific congenital illness was among the top five causes.

Endogenous causes continue to predominate among deaths to infants one to 27 days of age (Table 9). Three of the causes listed in Table 8 also appear in Table 9. The endogenous causes which predominate in this later neonatal period are those which may require more than a day to extract their toll. Hyaline membrane disease and congenital anomalies, for example, take on a particular importance in this stage. Asphyxia of newborn, such an important cause of early neonatal death, does not, of course, appear at all in Table 9, since it is a condition that strikes swiftly only a few seconds after birth. Perhaps the most notable characteristic of the table, however, is that

Table 8.—Leading Reported Causes of Death to Persons Under 24 Hours of Age, Louisiana, 1971-1973

Causes	Number of Deaths	Percent
All Causes	1,961	100.0
Immaturity, unqualified	417	21.3
Asphyxia of newborn, unspecified	317	16.2
Complications of pregnancy and childbirth other than difficult labor	230	11.7
Hyaline membrane disease	161	8.2
Respiratory distress syndrome	155	7.9
All Other Causes	681	34.7

Source: Compiled and computed from data in the Office of Public Health Statistics, *Vital Statistics of Louisiana*, Louisiana Health and Human Resources Administration, 1971 (Table XXXIII), 1972 (Table XX), and 1973 (Table XIX).

Table 9.—Leading Reported Causes of Death to Persons One to 27 Days of Age, Louisiana, 1971-1973

Causes	Number of Deaths	Percent
All Causes	1,352	100.0
Hyaline membrane disease	217	16.1
Birth injury without mention of cause	104	7.7
Congenital anomalies of heart	103	7.6
Respiratory distress syndrome	100	7.4
Pneumonia	85	6.3
Immaturity, unqualified	85	6.3
All Other Causes	658	48.6

Source: Compiled and computed from data in the Office of Public Health Statistics, *Vital Statistics of Louisiana*, Louisiana Health and Human Resources Administration, 1971 (Table XXXIII), 1972 (Table XX), and 1973 (Table XIX).

pneumonia appears in this list: an exogenous disease that is apparently pervasive enough to attack a significant number of infants within their first month of life.

Pneumonia is precisely the leading cause of postneonatal death, accounting for more than one-fourth of all deaths to infants in that age range (Table 10). Two different categories of accidents, which, needless to say, are exogenous causes, are also found in the list in Table 10. Congenital anomalies of the heart is the only one of the leading causes of postneonatal death that has clearly endogenous origins, accounting for a fairly high percentage of those deaths (10.5). Apparently, it is a congenital condition whose fatal consequences can be postponed considerably, perhaps through intensive medical attention.

Table 10.—Leading Reported Causes of Postneonatal Death, Louisiana, 1971-1973

Causes	Number of Deaths	Percent
All Causes	1,098	100.0
Pneumonia	281	25.6
Congenital anomalies of heart	115	10.5
Symptoms and ill-defined conditions	72	6.5
Accidents due to inhalation and ingestion of food or other object causing obstruction or suffocation	51	4.6
Other accidental causes, excluding fire and flames and mechanical suffocation	45	4.1
All Other Causes	534	48.7

Source: Compiled and computed from data in the Office of Public Health Statistics, *Vital Statistics of Louisiana*, Louisiana Health and Human Resources Administration, 1971 (Table XXXIII), 1972 (Table XX), and 1973 (Table XIX).

It would be of interest to examine once again the combined influence of sex, race, and residence on infant mortality levels, only this time separating the deaths according to the age of the deceased infants. Figures 12 and 13, which are comparable to Figure 8, present, respectively, neonatal and postneonatal death rates for each combined sex, race, and residence category. Looking first at Figure 12, it is obvious that the overall patterns found for all infant deaths also prevail among neonatal deaths. There are some slight differences, however. Unlike the situation in Figure 8, for example, there is one category of whites, males in nonadjacent parishes, that exhibits a slightly higher rate than two of the rates for nonwhites (females in metropolitan and in adjacent parishes). Among all infant deaths, it should be recalled, even the highest rate for whites was lower than the lowest rate for nonwhites. Also in contrast to the situation depicted in Figure 8, the neonatal rate for nonwhite males residing in nonadjacent parishes is much higher than the corresponding rate for females in the same race and residential category. The contrast between those two groups was not as marked in Figure 8.

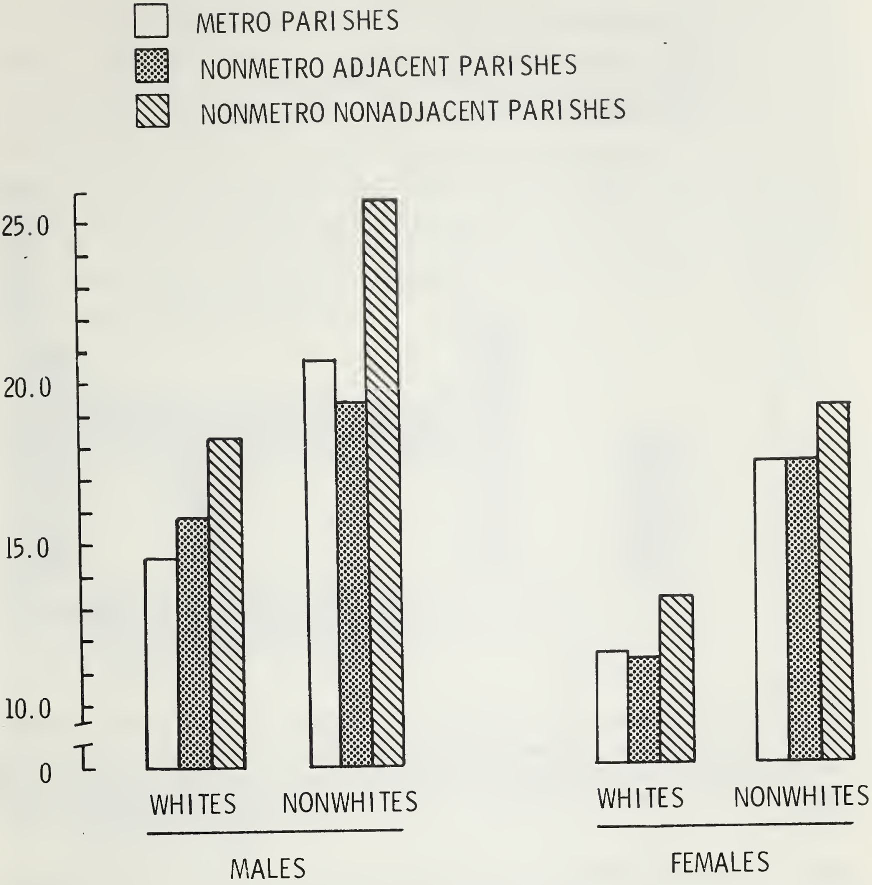

Figure 12.—Neonatal Mortality Rates by Sex, Race, and Residence, Louisiana, 1971 to 1973. (Source: Prepared from data in the *Vital Statistics of Louisiana*, Louisiana Health and Human Resources Administration, the Office of Public Health Statistics, 1971 (Tables VII and XXXV), 1972 (Tables III and XIX), 1973 (Tables I and XVIII).)

The bars in Figure 13 are, of course, smaller than those in Figure 12, given the lower levels of postneonatal mortality. Figure 13 is also not radically different from its predecessors. The racial differential is again predominant; in fact, there is a return to the exact pattern of Figure 8: all rates for whites are below all of the rates for nonwhites. The only minor discrepancy between this graph and the two previous ones is that within each of the two sets of bars for whites the residential differential is altered, with nonmetropolitan adjacent parishes exhibiting slightly higher rates than the rates for the other two residence categories. This relatively minor phenomenon, as well as the other somewhat less significant observations made in the previous paragraph concerning Figure 12, cannot be readily explained, especially since they may be the result of the instability of the

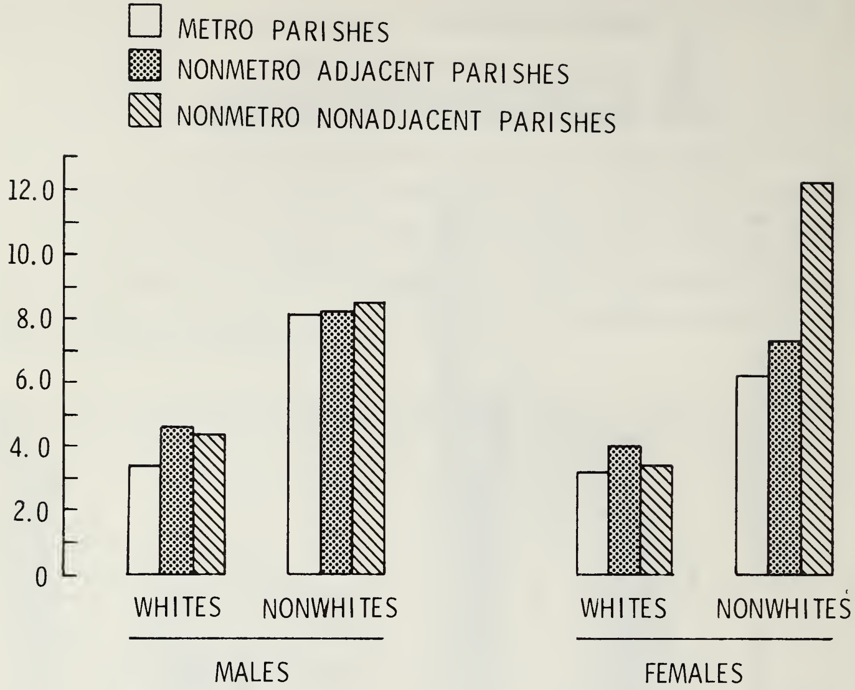

Figure 13.—Postneonatal Mortality Rates by Sex, Race, and Residence, Louisiana, 1971 to 1973. (Source: Prepared from data in the *Vital Statistics of Louisiana*, Louisiana Health and Human Resources Administration, the Office of Public Health Statistics, 1971 (Tables VII and XXXV), 1972 (Tables III and XIX), 1973 (Tables I and XVIII).)

relatively smaller numbers found in each specific category depicted in the two figures.

What is significant about the patterns in postneonatal deaths, however, is that for the first time in any of the three bar graphs, a rate for females is higher than the rate for males in the same race and residence category. The postneonatal rate for nonwhite females residing in nonadjacent parishes is substantially higher than the corresponding rate for males. But perhaps it is not the rate for females which is the anomaly, but the rate for males, which may be far too low. The explanation probably lies in the very high neonatal (and possibly fetal) mortality of males in this category, with the result that only the healthier babies entered the postneonatal stage while the less healthy ones did not manage to survive the high-risk conditions of their particular category during the first month of life. Full verification of this explanation will have to await a more detailed analysis, which is beyond the scope of this study.

Since the racial differential has proved to be the most significant of all the differentials examined in this study, it would be worthwhile to focus specifically on the contrast between the races in their levels of infant mortality according to age at death, in order to ascertain in which specific age category is the gap between whites and nonwhites at its maximum. It is precisely for that purpose that Figure 14 has been designed. Overall, the nonwhite infant mortality rate from 1971-1973 was 56.9 percent higher than the rate for whites. Looking at specific age categories, it is obvious that it is in the postneonatal period that the races exhibit the greatest contrast: the nonwhite rate exceeds the rate for whites by more than 110 percent. This is not at all an unexpected finding, since it is precisely in the postneonatal period when environmental conditions take on a particular importance as causes of death.

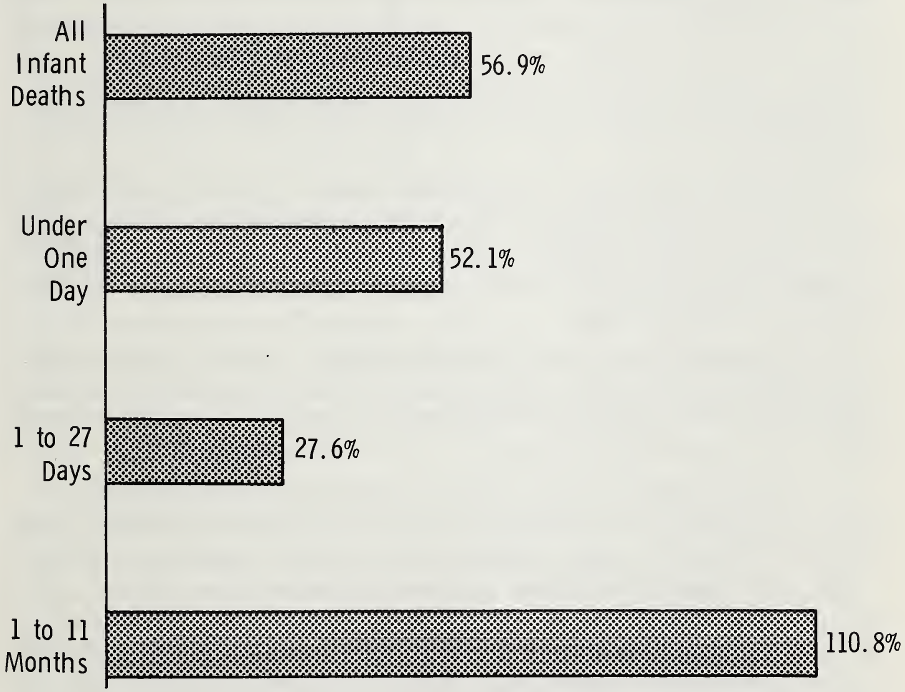

Figure 14.—Percent Excess of Nonwhite Over White Infant Mortality Rates by Age at Death, Louisiana, 1971 to 1973. (Source: Prepared from data in the *Vital Statistics of Louisiana*, Louisiana Health and Human Resources Administration, the Office of Public Health Statistics, 1971 (Tables VII and XXXV), 1972 (Tables III and XIX), 1973 (Tables I and XVIII).)

SUMMARY OF THE FINDINGS

1. In the three-year period from 1971 to 1973, the infant mortality rate for Louisiana was substantially above the national rate and slightly higher than the rate for the rest of the South. In terms of trends, in the 23-year period since 1950 the Louisiana rate was always higher than the rate for the United States, although the gap between the rates of the two populations has been narrowed somewhat during that time. In the early 1950s the level of infant mortality for the state was slightly lower than that of the rest of the South, with the reversal occurring at about 1956.

2. The infant mortality rate for Louisiana has declined significantly since 1950, from 35 to 21. It is noticeable, however, that since 1965 the rate of that decline has been much faster than in the earlier years. That trend is also exhibited by the national rate. For Louisiana, it was postulated that this recent sharper decline was primarily the result of a noticeable shift towards women having fewer children (a reduction in the number of births in the higher birth orders) and having them in the more favorable maternal ages (20 to 34).

3. Although changes in classification make it very difficult to study trends in the leading causes of infant death, it appears that, overall, these have changed only slightly in the period since 1950. In 1971-1973, pneumonia, an exogenous disease, was the third leading cause of death among Louisiana's infants.

4. As expected, male infants exhibited higher levels of mortality than female infants. The rates for both sexes have declined at about the same speed since 1950, so that there have been no appreciable changes in their relative standings since that time.

5. In the period from 1971 to 1973, nonwhites exhibited substantially higher infant mortality levels than whites. This is undoubtedly associated with the fact that a higher proportion of nonwhite infants were born to "high-risk" mothers (women in unfavorable maternal ages and with a history of repeated pregnancies with short birth intervals). The greater proportions of illegitimate and low birth-weight infants among nonwhites are also factors related to their higher levels of infant mortality. The racial differential in infant mortality has prevailed in Louisiana at least since 1950. It was found, however, that the gap between the races has been narrowed, primarily because nonwhites have recently experienced faster rates of decline than whites, particularly since 1965. The most important single factor accounting for that faster decline among nonwhites is probably the substantial drop in the proportion of higher-order births in that population. With regard to differences between the races in the causes of death, it was found that among whites the leading causes of infant death were endogenous, while among nonwhites pneumonia (presumably an exogenous disease) was the second leading cause of infant deaths during 1971-1973.

6. Of the three residential categories examined, nonmetropolitan parishes which are not adjacent to metropolitan parishes exhibited the highest rates of infant mortality, while the metropolitan parishes were lowest in 1971-1973. That situation has prevailed since 1950. It is noteworthy that since 1965 nonmetro parishes adjacent to S.M.S.A.s experienced the fastest decline, so that by the 1970s their levels were more similar to the rates for metropolitan parishes than to the levels for nonadjacent parishes.

7. A look at the combined effect of sex, race, and residence yielded the expected results: nonwhite infant males residing in nonadjacent parishes exhibited the highest rates of mortality, whereas white infant females residing in metropolitan parishes exhibited the lowest rates. The preeminence of the racial differential was obvious: the highest combined sex and residential rate for whites (males in nonadjacent parishes) was lower than the lowest rate for nonwhites (females in metropolitan areas).

8. There is no concentration of either high or low parish rates in any particular region within the state. In terms of trends, there have been important changes in the parish differentials since 1950. Along with an overall decline in infant mortality, there has been a reduction in the range separating the parishes with the highest and the lowest infant mortality rates. What is interesting, however, is that the rank order of parishes according to infant mortality in 1971-1973 bears little resemblance to the rank order of parishes in the 1949-1951 period. This was occasioned by the widely-varying rates of decline exhibited in that 23-year period by Louisiana's parishes. Additionally, some parishes did not register any appreciable change in their rates, while a few others actually experienced an increase in their levels of infant mortality since 1950.

9. In Louisiana, neonatal rates substantially exceeded postneonatal rates of infant mortality during 1971-1973. In fact, the highest mortality rates were found among infants under one day of age. The difference between neonatal and postneonatal rates was smaller in 1950 than in 1973. In the span of time separating those two years, the rate for the latter age-at-death category has declined more rapidly than that for neonatal deaths. As expected, causes of infant death varied considerably by age at death. Overall, endogenous causes predominate among neonatal deaths, while exogenous causes are prominent in the postneonatal period. Pneumonia was the leading cause of postneonatal death, accounting for more than one-fourth of all losses in that age category. When examining the influence of sex, race, and residence on the incidence of neonatal and postneonatal deaths, some differences between the two age-at-death groups were noted, but overall those disparities were not of major consequence. Additionally, it was discovered that it was in the postneonatal stage that the contrast between the races was more pronounced, with the rate for nonwhites exceeding the rate for whites by more than 110 percent.

CONCLUSIONS AND IMPLICATIONS

Many sociologists attempt to refrain from making judgements about the relative desirability of the social phenomena they analyze, frequently without success. In this study, one value judgement which the authors obviously make and which permeates this entire report is that human life is precious and its conservation is desirable. That view is undoubtedly shared by most people. The relatively rapid acceptance and diffusion throughout the world of modern life-prolonging technology is evidence that the value systems of virtually all societies include the notion that life is preferable to death and that the latter should be avoided as long as possible.

This is no less true, and perhaps even more so, of deaths to very young persons. Mortality in general is a woeful subject, but infant mortality has an especially lamentable quality. Perhaps it is so because we perceive that so many adult deaths are indirectly self-inflicted: the results of actions by conscious and mature human beings who unintentionally endanger their own health and safety in a multitude of ways. In contrast, deaths to infants and small children occur as a result of factors which are totally beyond their control and for which they have no responsibility: the victims are pathetic, helpless beings who, far from being able to influence their own destinies, are usually not even aware of their own existence. Even if we attempted to take the role of detached scientists, few of us would fail to be touched by the pitiful events which the tables and graphs in this bulletin so coldly depict. The 4,411 infant deaths occurring in Louisiana from 1971 to 1973 represent, some to a greater or lesser degree than others, 4,411 cases of tragedy and heartbreak for all persons involved. Few Louisianians would disagree with the idea of reducing the incidence of infant deaths.

Can the state's present level of infant mortality be reduced further? If so, how can it be accomplished? Most of the findings of this study have implications for the answer to these basic and crucial questions. It is, of course, very doubtful that infant mortality will ever be eliminated anywhere in the world. In addition to the fatalities from the inevitable accidents, there are also the deaths due to endogenous causes which not even the best of medical care can avert. While medical science has been able to reduce somewhat the incidence of deaths that result from certain congenital conditions, as well as effectively control many infectious and contagious diseases which previously figured prominently among the causes of infant death, it can do very little, at least at its present level of technology, to save many newborn infants whose bodies simply cannot perform essential functions.

Although the incidence of infant deaths in any given population cannot be lowered to zero, three major findings of this study indicate that it is possible for Louisiana's infant mortality rate to be be reduced substantially below its current level: (1) the state's rate is higher than those of the nation and the rest of the South; (2) there are noticeable differences in the incidence of infant deaths between different populations within the state; and (3) pneumonia, presumably a preventable and curable disease, still ranks high among the causes of all infant deaths in Louisiana.

It is doubtful that the differences in infant mortality between Louisiana and other states, as well as the contrasts within the state between racial, residential, and parish populations, can be attributed to biological factors. With the possible exception of the differentials according to the age and sex of the infants, all the other differentials analyzed in this study are determined primarily by sociocultural forces. Consequently, many infant deaths occurring in the state are preventable: while biological factors are fairly immutable, sociocultural conditions, being the products of human association and interaction, can be much more readily modified through human intervention.

The findings of this study indicate the paths that those intervention efforts can take. For one thing, the populations that face the highest risk of incurring infant deaths have been identified. The nonwhite populations must be particularly singled out, given the significance of the race differential. Certain residential categories and parishes have also been identified as suffering from infant mortality levels which are higher than average. Intervention efforts should be directed at those high-risk populations.

The findings of this study also suggest that pneumonia has to be taken seriously as a cause of infant death in the state. During 1971 to 1973, it was the third leading cause of all infant deaths in the state, and the second leading cause of death to nonwhite infants. It was also found to be the most important cause of death in the postneonatal period, responsible for more than one-fourth of all deaths in that age group. This is a lamentable situation, especially when it is a disease which in many cases can be prevented if mothers take proper precautions in caring for their infants. Physicians and public health personnel should instruct mothers on such precautions. Perhaps the various information channels of the Division of Maternal and Child Health, especially the Pierre the Pelican newsletter, could be used to acquaint mothers on ways of preventing pneumonia and detecting its early symptoms.

Another avenue for intervention efforts is suggested in this report: an intensification of the trend towards women having fewer children and having them in the more favorable maternal ages. The beginning of that trend in the mid-sixties was found to be a major factor responsible for much of the recent decline in Louisiana's infant mortality rate. But there are still many births, particularly among nonwhites, which occur in the high-risk categories in terms of both maternal age and birth order. Fertility control measures should therefore be an integral part of any attempts to curb the incidence of infant deaths. The Teenage Pregnancy Project, recently instituted by the Louisiana Division of Maternal and Child Health, is an excellent step in the right direction, as are the other family planning projects under the administration of that Division. Their support and scope should definitely be expanded.

Although we can safely assume that improvements in the quality, quantity, and distribution of prenatal and postnatal medical care in the state will lead to a reduction in the levels of infant mortality, the present research is not sufficient, at least in its present stage, for making specific recommendations in those areas. The reason for this is simply that such factors have not been looked at in this study. This has been an analysis of levels, trends, and differentials. It is therefore a demographic study—an essential first step in understanding the incidence of infant deaths in the state. We have looked at the interrelationships between infant mortality and demographic variables and attributes such as race, residential status, age and sex of the infant, and geographic (parish) differentials. We have also examined the influence of other factors which are considered demographic: causes of death, maternal age, and birth order. Within the demographic scope of the study, implications have been drawn regarding target populations for intervention efforts, the necessity to control the incidence of pneumonia, and improvements in the maternal-age and birth-order situation. Further research, already planned, is needed in order to go beyond the demographic system and ascertain those factors in the social and economic structure which affect the observed levels, trends, and differentials. It is possibly the case, for example, that race is a significant differential only because it reflects primarily disparities in socioeconomic status, disparities which largely determine the contrasts between the two races in the incidence of both births and deaths. Are there indeed socioeconomic differentials in the incidence of infant deaths? If socioeconomic status is controlled, would the differences according to race, residence, and parish disappear? How important is the role of prenatal and postnatal care in reducing infant mortality? Does socioeconomic status affect the availability of that care to mothers and infants? If so, to what extent and how? These are only a few of the questions that future research will tackle in order to formulate specific conclusions regarding the role of social and cultural factors, such as medical attention and socioeconomic status, in influencing infant mortality levels. Those conclusions will undoubtedly have implications for intervention techniques designed to reduce the incidence of infant deaths.

The present study represents a necessary and basic first step in understanding the problem of infant mortality in the state. We now know its extent, recent trends, differences between various sub-populations of the state, and the leading official causes. We have also learned that the levels can be reduced much further and we have pointed to possible avenues of future intervention efforts and research endeavors.

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UNOFF FROM A PASTURED WATERSHED IN LOUISIANA

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Preface

This publication is derived from a comprehensive analysis and summary of work under Experiment Station Project H-1104, "Factors Affecting Water Yields from Small Watersheds and Shallow Ground Aquifers." Louisiana Project H-1104 participated in Regional Project S-53, which was established as a coordinating body for a Southern Region study of surface and ground water hydrology of small agricultural watersheds. This regional project was initiated in July, 1962. Objectives were (1) to correlate runoff rates and yields to watershed characteristics, and (2) to correlate shallow ground water yields to site and climatic conditions. Project H-1104 was concluded in June, 1975. Project records indicate that the following persons participated in the project during its 13-year life: J. B. Allen, H. T. Barr, H. L. Barousse, H. J. Braud, C. E. Carter, J. L. Chesness, M. Fairchild, E. A. Landry, S. T. Lin, W. F. Lytle, R. L. McFall, J. W. D. Robbins, W. Talbot, and J. E. Wimberly.

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Runoff from a Pastured Watershed In Louisiana

TOM S. CHISHOLM[1]

Introduction

Knowledge about runoff rates and volumes can be of value to many people. When rainfall occurs, an agricultural landowner would like to retain as much water as he can effectively utilize and dispose of the excess water with minimum cost and inconvenience. To accomplish this objective, the landowner needs information about rainfall and runoff patterns. Likewise, persons downstream are affected by runoff from upstream watersheds. Attention is frequently focused on downstream flooding or water shortages. However, these situations can be best understood and controlled if thorough consideration is given to upstream conditions.

The agricultural sector can play a major role in achieving more effective utilization of our soil and water resources. It is necessary that the agricultural industry develop practices that will increase water use efficiency and at the same time enhance dependability of water yields for downstream users. Prerequisite to such practices is a more basic understanding of the factors affecting the hydrologic response of agricultural watersheds.

In engineering literature there are numerous empirical and semiempirical formulas that were developed to predict runoff volumes and peak rates. Chow *(1)*[2] made a thorough review of 66 such methods of runoff computation. Kuichling *(5)* was apparently the first to utilize the rational formula in which peak discharge rate is given as a function of the drainage area, rainfall intensity, and a runoff coefficient that characterizes the physical features of the drainage area. Cook *(2)* pursued another approach that predicted peak runoff rates based upon the watershed characteristics of relief, infiltration, vegetal cover, surface storage, and area. Recently a number of hydrologic models have been developed. Gray *(4)*, Crawford and Linsley *(3)*, Wei *(7)*, and others have developed models that synthesize hydrographs and predict overland flow. Actual watershed records are required to adjust these models for predicting the response of small agricultural watersheds. Similarly, quantitative measurements are required to establish relationships between physical characteristics and model parameters.

This report should contribute in at least a small way to the better understanding of the hydrologic performance of a small relatively flat watershed that is maintained in pasture. Various items in this report may be of interest to landowners, water control designers, and researchers. In addition to the information contained in the main body of the report, considerable amounts of basic data are also presented in the appendices.

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[2] Italic numbers in parentheses refer to Literature Cited, page 10.

Objective

The objective of Louisiana Project H-1104 was to correlate runoff rates and volumes to rainfall rates and volumes for a relatively flat 50-acre pastured watershed in southern Louisiana.

Procedure

In 1962 this watershed study was initiated on a 50-acre pastured area at the Ben Hur Farm in Baton Rouge, Louisiana. The land slope was approximately 0.3 percent, and all runoff drained through a single outlet. Three recording rain gauges provided information on rainfall amounts and rates; a recording H-flume gave data on runoff rates and durations. The details associated with the watershed and its instrumentation are contained in Appendix A.

Analysis was made of 43 storms that occurred during the period 1966 through 1969. Records were not complete for all storms that occurred during this 4-year period, but storms covering all seasons of the year are included, with rainfall amounts varying between 0.20 and 6.80 inches per storm.

For each of the 43 storms the following data are listed in Appendix B:

1. Storm number.
2. Date
3. Rainfall amount in inches.
4. Rainfall duration in minutes.
5. Rainfall 30-minute duration maximum intensity in inches per hour.
6. Runoff amount in inches.
7. Runoff peak rate in inches per hour.
8. Number of minutes that runoff exceeded a rate of 0.001 inches per hour.
9. Number of minutes that runoff exceeded a rate of 0.010 inches per hour.
10. Number of minutes from rainfall start to runoff peak for storms with reasonably uniform rate of precipitation.
11. Number of minutes from rainfall peak to runoff peak for storms with clearly defined peaks.

In addition, basic weather data was available from a station approximately one-half mile from the watershed. The following monthly summary data are given in Appendix C:

1. Average temperature in degrees Fahrenheit.
2. Rainfall in inches.
3. Pan evaporation in inches.

4. Wind movement in miles.

Results

The basic rainfall and runoff data for the 43 storms were analyzed using various techniques in an attempt (1) to gain insight into the relationships between rainfall, runoff, and watershed characteristics, and (2) to express some of these relationships in forms that might be useful to other persons.

First, two generalized graphs will be presented that were obtained by considering all the storms together. Next, two specific storms will be discussed to give some indication of the variation in watershed responses. Finally, comparisons will be made between this study and a similar study that was conducted on nearby cropland.

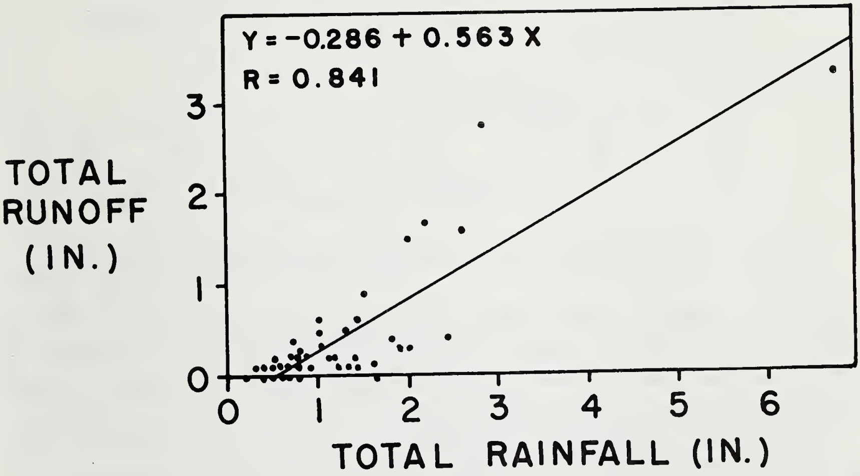

Figure 1.—Relationship between rainfall amount and runoff amount.

Figure 1 depicts a generalized relationship between rainfall amount and runoff amount. This linear regression relationship could be thought of as an "average" response of the watershed, with a reasonably high correlation coefficient of 0.841. The graph indicates that a rainfall of less than 0.5 inches would not normally result in appreciable runoff, whereas a 4-inch rainfall could be expected to result in almost 2 inches of runoff. Likewise, Figure 2 shows a generalized relationship between rainfall amount and runoff peak rate. This graph indicates that the watershed acts to prevent high runoff rates. For example, consider the 4-inch rainfall and 2-inch runoff just mentioned. Two inches of runoff would be expected to discharge from the watershed, but Figure 2 indicates a maximum discharge rate of 0.3 inches per hour. It is desirable to have a low peak runoff rate because smaller drainage channels can be used. Basically, Figure 1 indi-

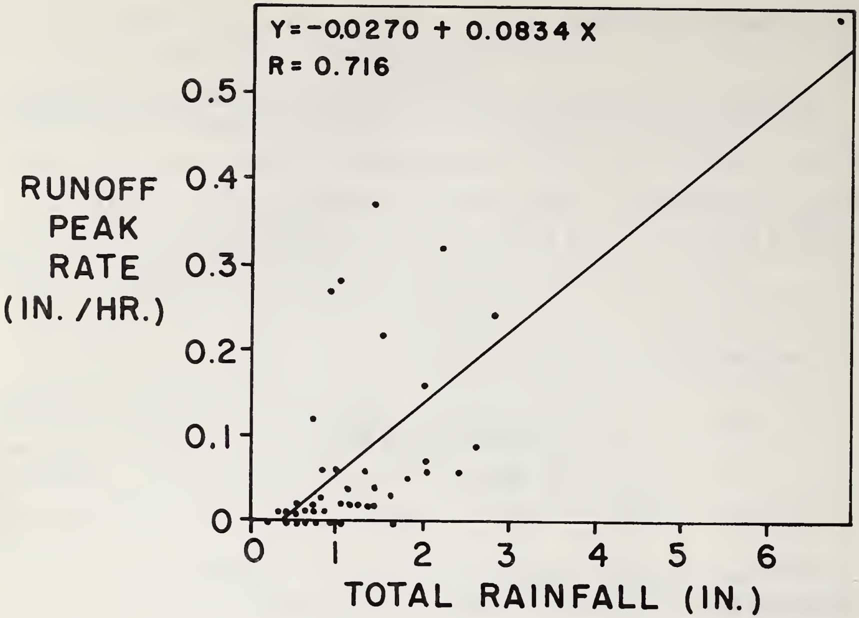

Figure 2.—Relationship between rainfall amount and runoff peak rate.

cates the *amount* of runoff that can be expected from a rain storm, and Figure 2 indicates the *maximum rate* of runoff that can be anticipated. These graphs could be used to derive approximate estimates of runoff amounts and peak rates for watersheds similar to the one that was studied.

Figure 3 shows rainfall and runoff rates vs. time for two specific storms. It will be noticed that total area under each curve is directly proportional to total amount of rainfall or runoff as applicable. Figure 3a is from a gentle rainfall on moist soil, resulting in high runoff. Figure 3b is from a heavy rainfall on dry cracked soil, resulting in low runoff. Summary data for the two storms are given in Table 1. For the winter storm (Figure 3a), the runoff amount was 67 percent, and the runoff peak rate was 37 percent of

Table 1.—Data summary for the two specific storms represented in Figure 3

Type of information	Fig. 3a	Fig. 3b
Storm number	13	34
Date	1-13-67	6-18-68
Soil moisture regime	moist	dry
Rainfall amount (inches)	0.95	2.45
Rainfall duration (minutes)	91	218
Rainfall 30-minute duration maximum intensity (in./hr.)	0.77	2.29
Runoff amount (inches)	0.64	0.36
Runoff duration (minutes)	1660	1000
Runoff peak rate (in./hr.)	0.285	0.063

Figure 3.—Rainfall and runoff rates vs. time for two specific storms.

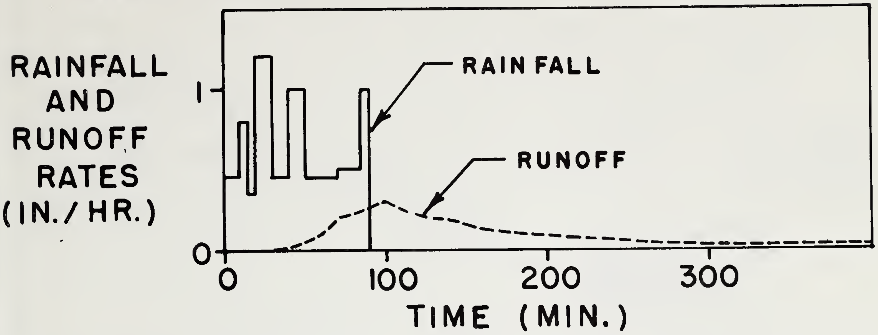

Figure 3a.—Gentle rainfall on moist soil, resulting in high runoff.

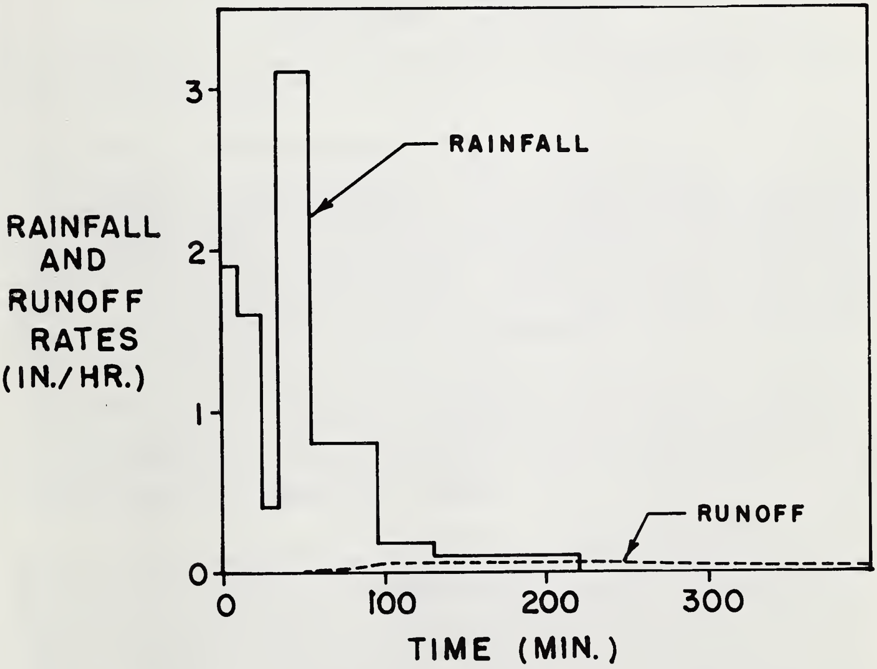

Figure 3b.—Heavy rainfall on dry cracked soil, resulting in low runoff.

the 30-minute duration maximum intensity rainfall. The first value relates runoff amount to rainfall amount; the second value relates runoff rate to rainfall rate. The corresponding values for the summer storm (Figure 3b) were 15 percent for the amount and 3 percent for the rate. These watershed responses illustrate two characteristic extremes. In the winter it is common for the soil to remain very moist due to low evaporation, and storms tend to be of low intensity. By contrast, in the summer deep cracks frequently form

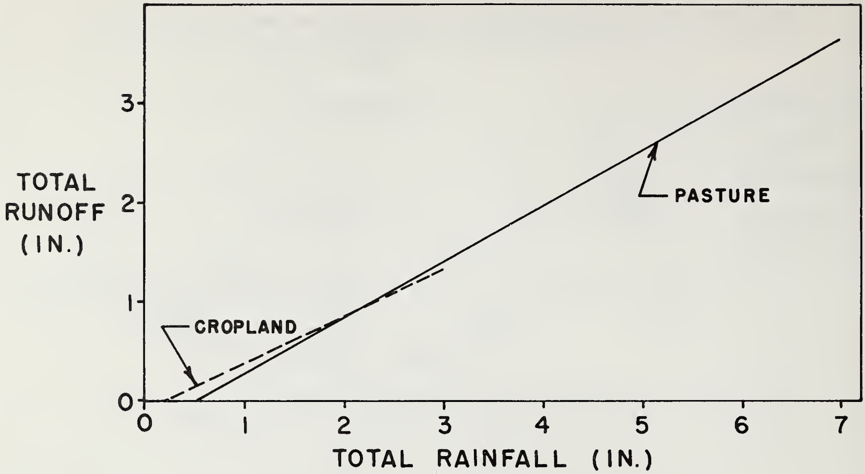

Figure 4.—Relationship between rainfall amount and runoff amount for pasture and for cropland.

in the soil because of its high content of montmorillonite clay, and storms tend to be of high intensity. Figure 3 illustrates the pronounced effect apparently caused by soil cracking, but this effect does not eliminate the usefulness of the relationships indicated in Figures 1 and 2. Figures 1 and 2 give reasonably good ''average'' estimates based only on simple relationships with rainfall. Figure 3 would tend to indicate that more complex relationships involving antecedent soil moisture would give more accurate estimates for specific storms on this watershed. Some soil moisture information was recorded in this study, but complete data were not maintained. An additional observation can be made from Figure 3a. If it is considered that a uniform rainfall occurs until the runoff peak rate is reached, then a time of concentration for the watershed can be estimated at approximately 90 to 100 minutes.

Figures 4 and 5 allow comparisons to be made between this watershed study and a similar study by Laflen and Saveson (6) which was conducted on nearby cropland. The cropland was precision graded to have slopes ranging between 0.10 and 0.25 percent in the direction of the rows, which ranged in length from 500 to 1,100 feet; the reported data available were for a period 1962 through 1964. Figure 4 indicates that similar *amounts* of runoff can be expected from the pasture and the cropland, but Figure 5 indicates that much greater *peak rates* of runoff can be anticipated for the cropland. In Figure 5 the regression line for pasture has a low correlation coefficient (0.331), but this line was presented mainly for comparison with the regression line for cropland, which was reported in this manner and had a correlation coefficient of 0.86. For the pasture data, runoff peak rate is apparently better related to rainfall amount as indicated in Figure 2.

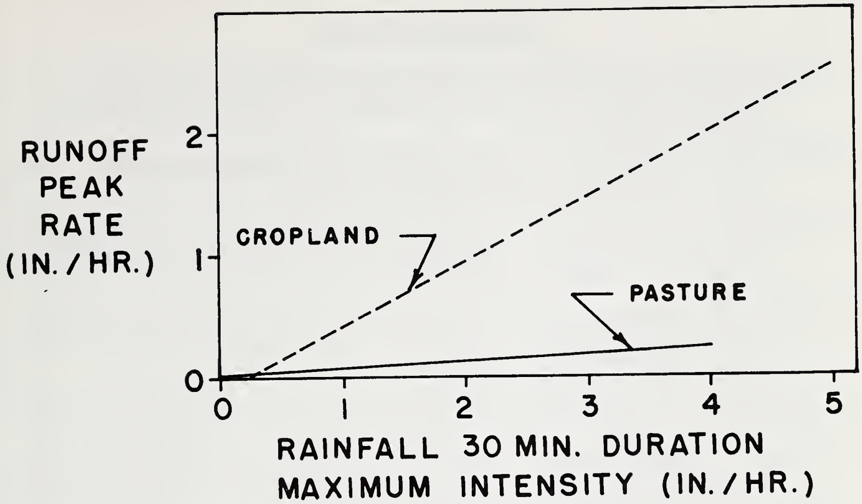

Figure 5.—Relationship between rainfall intensity and runoff intensity for pasture and for cropland.

Summary

A watershed study was established on 50 acres of pastured land that had a slope of approximately 0.3 percent. Analysis was made of rainfall and runoff data from 43 storms that occurred during the period 1966 through 1969. Records were not complete for all storms that occurred during this 4-year period, but storms covering all seasons of the year were included. Some observations are:

1. Maximum rainfall amount for a storm was 6.80 inches, which resulted in the maximum runoff of 3.33 inches and the highest peak runoff rate of 0.592 inches per hour. From a probability standpoint, this storm would have a return frequency of 3.9 years.

2. For the 43 storms, the total rainfall was 56.98 inches and the total runoff was 19.72 inches, indicating that the runoff was 34.6 percent. For storms that occurred during the period October through March, the corresponding percent was 60.7; for storms that occurred during the period April through September, the corresponding percent was 25.3.

3. For the 43 storms, the average rainfall duration was 8.9 hours and the average runoff duration was 25.1 hours. For storms that occurred from October through March, the average rainfall duration was 18.3 hours. For storms that occurred from April through September, the average rainfall duration was 5.5 hours.

4. The longest duration of runoff was 152 hours, which resulted from a rainfall of 2.85 inches with a duration of 82.3 hours on a very wet soil. The runoff amount was 2.77 inches, or 97 percent of the rainfall amount.

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APPENDIX A

Detailed Description of 50-acre Pastured Watershed

Location: East Baton Rouge Parish, Baton Rouge, Louisiana, Township 8 South, Range 1 West.

Area: 50 acres (rectangular, 1,000 feet x 2,200 feet).

Slopes: Graded to 0.3 percent.

Soils: Mixed silty and clay recent alluvium of the Mississippi River.

Soil profile	Percent of area	Avg. depth (in.)	Description		
			Type	Structure	Permeability (in./hr.)
Commerce loam	66	4	Loam	Med. granular	0.06
		12	Clay loam	Coarse platy	0.53
		18	Fine sandy loam	Med. blocky	0.12
		27	Clay loam	Weak blocky	1.00
Mhoon silty clay loam	34	3	Silty clay loam	Med. granular	0.21
		7	Clay loam	Med. platy	0.21
		14	Silty clay loam	Weak blocky	0.01
		23	Clay loam	Massive friable	0.01

Erosion: Erosion Class One.
Land Capability: Class One.

Geology: The recent alluvium is a huge mass of stream deposits that partially fills the Mississippi entrenched valley system. The average thickness of the southern half of the alluvium (south of latitude 33°) is 138 feet. The alluvium consists of a sequence of sediments that grades irregularly upward from coarse graveliferous sands into progressively finer deposits of sands, silts, and clays.

Surface Drainage: Excellent; length of principal waterway approximately 2,200 feet, graded watershed surface flow to graded field waterways. Principal waterway has a slope of 0.1 percent and runs parallel to and 100 feet from one side of the watershed. Fifteen field waterways with a slope of 0.3 percent run perpendicular to the principal waterway.

Character of Flow: Surface runoff-intermittent.

Instrumentation: Runoff: 4.5 foot deep precalibrated H-flume equipped with two Belfort FW-1 recorders (6-hour and 12-hour time scale). Rainfall: Three Belfort weighing type recording rain gauges, one with 6-hour time scale and two with 24-hour time scales.

Watershed Conditions: Permanent pasture reworked and seeded on a 5-acre basis every 5 years. Predominantly employed species are dallisgrass, bermudagrass, S-1 clover, and Persian clover.

APPENDIX B

Rainfall and Runoff Data for 43 Storms on 50-acre Pastured Watershed

Storm number	Date	Rain amount (in.)	Rain duration (min.)	Rain 30-min. duration max. intensity (in./hr.)	Runoff amount (in.)	Runoff peak rate (in./hr.)	Time that runoff rate was above 0.001 in./hr. (min.)	Time that runoff rate was above 0.010 in./hr. (min.)	Time from rain start to runoff peak for uniform storms (min.)	Time from rain peak to runoff peak where applicable (min.)
1966										
1	5-1	0.80	120	0.81	0.10	0.030	617	240	125	—
2	6-14	0.50	51	0.66	T	0	0	0	55	—
3	6-15	1.20	37	2.29	0.08	0.022	671	151	—	68
4	7-2	1.30	145	2.30	0.07	0.057	537	141	—	34
5	7-4	0.87	102	1.53	0.21	0.268	1,080	262	—	19
6	7-9	1.40	47	2.68	0.60	0.374	1,128	498	—	28
7	7-15	0.55	43	0.96	T	0	0	0	62	—
8	7-18	0.20	13	0.40	T	0	0	0	—	—
9	7-20	0.70	30	1.36	0.19	0.019	1,108	415	—	28
10	7-23	1.00	325	1.26	0.28	0.019	1,510	756	—	—
11	8-5	0.81	196	0.63	0.01	0.002	19	0	—	19
12	8-9	0.85	600	0.84	0.01	0.002	26	0	—	18

1967										
13	1-13	0.95	91	0.77	0.64	0.285	1,660	353	106	—
14	2-6	2.25	850	0.73	1.73	0.317	2,837	881	—	—
15	2-11	0.50	1,840	0.30	0.05	0.007	761	0	—	—
16	2-20	0.70	85	1.00	0.42	0.124	1,254	367	—	—
17	4-14	6.80	1,518	2.57	3.33	0.592	4,474	1,512	—	—
18	5-1	1.45	205	1.28	0.21	0.016	942	582	—	—
19	5-3	0.65	303	0.27	0.07	0.011	616	72	—	—
20	5-4	1.47	202	0.90	0.87	0.219	1,244	645	—	—
21	6-1	1.45	325	1.90	0.17	0.039	1,015	356	—	58
22	6-20	1.10	80	1.67	0.18	0.041	901	320	96	—
23	6-7	1.60	188	2.16	0.14	0.029	787	252	—	16
24	8-26	2.05	540	1.26	0.31	0.070	1,159	463	—	—
25	9-12	0.30	11	0.60	0.06	0.008	804	0	—	—
26	12-9	2.00	605	0.89	0.32	0.060	2,100	395	—	—
27	12-10	0.80	107	1.19	0.28	0.060	1,013	318	—	90
1968										
28	2-17	0.84	885	0.13	0.06	0.007	834	0	—	—
29	2-27	0.52	165	0.37	0.16	0.018	1,404	205	—	—
30	3-5	0.45	510	0.11	0.10	0.013	1,113	157	—	—
31	4-4	0.45	690	0.47	T	0	0	0	—	—
32	4-9	0.70	285	0.73	0.02	0.002	442	0	—	—
33	4-29	0.50	33	0.97	T	0	0	0	—	—
34	6-18	2.45	218	2.29	0.36	0.063	1,000	486	111	—
35	7-22	1.55	221	2.26	0.01	0.001	51	0	—	—
36	8-5	1.75	259	1.75	0.38	0.052	1,100	617	—	—
37	8-12	2.55	420	3.20	1.63	0.086	1,600	1,328	—	—
38	8-13	0.70	212	0.58	0.07	0.007	864	0	—	—
39	8-22	1.27	1,525	0.90	0.49	0.016	4,470	503	—	—
40	11-30	2.85	4,940	1.06	2.77	0.238	9,120	3,221	—	—
41	12-22	1.98	1,640	0.55	1.50	0.165	7,485	2,265	—	—
1969										
42	5-5	1.16	270	1.62	0.18	0.020	1,648	219	—	—
43	5-7	0.95	1,640	0.80	0.54	0.059	3,937	627	—	—

APPENDIX C

Monthly Summary of Weather Data Recorded ½-mile from 50-acre Pastured Watershed

Month	Average temp. (°F)	Rain amount (in.)	Pan evapo-ration (in.)	Wind move-ment (miles)	Month	Average temp. (°F)	Rain amount (in.)	Pan evapo-ration (in.)	Wind move-ment (miles)
1966					1968				
Jan.	46.4	9.89	1.93	2,845	Jan.	50.2	1.74	2.00	2,050
Feb.	50.8	16.22	2.64	2,491	Feb.	46.3	2.42	3.17	2,016
Mar.	58.6	1.69	4.90	2,231	Mar.	56.0	2.73	4.27	2,139
Apr.	68.4	5.70	6.70	2,747	Apr.	69.7	2.56	5.43	2,146
May	74.8	3.21	6.36	1,889	May	73.8	4.56	6.82	1,848
June	78.4	2.63	8.48	1,526	June	79.0	5.29	7.61	876
July	82.1	7.04	5.74	960	July	80.1	3.07	6.78	702
Aug.	79.4	3.29	5.31	809	Aug.	80.6	7.09	7.13	726
Sept.	76.7	1.28	4.84	772	Sept.	75.6	1.34	5.83	914
Oct.	66.4	2.95	4.27	1,710	Oct.	69.7	0.11	5.47	1,361
Nov.	62.0	1.64	3.61	1,613	Nov.	56.4	6.74	2.81	2,035
Dec.	52.0	2.37	2.13	2,055	Dec.	50.4	7.52	—	2,175
Ann.	66.3	57.91	56.91	21,648	Ann.	65.7	45.17	—	18,989
1967					1969				
Jan.	51.3	3.60	2.06	1,880	Jan.	52.4	1.63	2.81	—
Feb.	50.7	4.68	2.45	1,943	Feb.	52.9	6.52	2.31	2,038
Mar.	63.7	1.89	5.32	1,953	Mar.	52.8	4.72	3.60	2,238
Apr.	72.3	5.83	7.10	1,939	Apr.	68.2	9.58	5.29	1,767
May	72.1	4.58	6.86	1,959	May	74.3	4.05	5.45	1,439
June	79.2	5.14	7.09	1,045	June	80.5	0.51	7.58	1,273
July	78.8	5.40	5.52	796	July	83.1	6.58	5.41	799
Aug.	78.7	5.31	5.62	872	Aug.	80.3	2.20	6.05	729
Sept.	73.8	3.10	5.00	1,176	Sept.	75.7	0.78	5.71	780
Oct.	65.1	1.45	5.20	1,222	Oct.	68.8	6.41	4.52	1,944
Nov.	59.1	0.13	3.53	1,506	Nov.	56.7	0.73	2.83	1,589
Dec.	56.2	5.65	1.79	2,216	Dec.	52.9	3.37	1.65	1,757
Ann.	66.8	46.76	57.54	18,507	Ann.	66.6	47.08	53.21	—

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